Hilltop Hanover Farm - Mini-Meadow Reconstruction 2024

A report by Lily Arbisser Shorr, Native Plant Gardener Intern at Hilltop Hanover Farm from June to November 2024

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Description of the project:

Meadow size: 3500 sq ft (encompasses a future walkway and an internal sitting/gathering area which will be mown once the meadow is established)

Experiment: Four quadrants featuring four different site preparation methods; each quadrant is ~875 sq ft (see Table 1)

Timing:

- Mid-summer and early September prep (the project initiated in early July, but future projects might benefit from an earlier start date to help kill existing vegetation more effectively depending on method used.)
- September 23rd site prep and September 27th fall dormant seeding[1] w/ nurse crop[2] and straw/chaff cover[3] - We wanted to seed immediately after site prep but seed availability and weather delayed the seeding to the 27th. (Note: the early deadline for seeding was chosen because the site is on a slope, and it is advised to seed earlier to help establish the nurse crop for erosion control.[4])

Thank you to everyone at Hilltop Hanover Farm (HHF) who helped me with this project–especially to Adam Choper (Farm Director), Emily Rauch (Native Plants Program Manager), Lindsey Feinberg (Native Plants Curator), and Melissa Hammel and Skyler Young (Native Plants Crew Members).

Also, please note that brevity was not the goal with this report. Sources are cited as much as possible, and the document is intended to provide resources and reading material for other people attempting similar reconstruction efforts.

[1] Dormant seedings allow for earlier spring germination and root establishment the following growing season.
[2] Nurse crop: an annual crop used to help establish a perennial crop. Nurse crops buffer perennial seedlings, protecting them from wind while providing some shade and erosion control. Prairie Moon notes the reason people use a grass species as the nurse is because it provides some shade but doesn't shade out seedlings entirely.
[3] The nurse crop should stabilize the site, but we also plan to add a minimal layer of clean chopped straw (we will be using chaff from our native seed collections and supplementing the chaff with Mainely Mulch) after seeding.
[4] "Erosion-prone sites should be planted with a nurse crop and covered with weed-free straw mulch to prevent seed and soil loss. Steep slopes and areas subject to water flow should be protected with erosion blankets, selected to match the expected water volumes and velocities. Fall planting on erodible sites should be completed by September 15 in order to encourage sufficient growth of nurse crops to stabilize the soil." (Diboll, "Five Steps to Successful Prairie Meadow Establishment," p. 5)

Step 1: Site prep

Deadlines and site prep materials needed (there is a **SEPARATE** materials list for seeding on page 11):
The materials are repetitiously listed in Table 1.

Rentals:

- ☑ Sodcutter (by Sept. 23rd AM)
- ☑ Dethatcher/Power rake (by Sept. 23rd AM)

Purchase:

- ☑ Topsoil (weed seed free) (13.5 cubic yards [ordered 20 cubic yards from D.F. Stone Contracting Ltd. to have extra])[5]
- ☑ Soil amendments: Potassium (on site already). UConn soil test (Appendix A) recommends amending with: 35 lbs (75 cups) of 10-10-10 AND 17.5 lbs (35 cups) of 0-0-60 (muriate of potash) OR 52.5 lbs (70 cups) of 0-0-22 (sul-po-mag). The potassium amendment will be distributed in the spring around April before the seedlings germinate to encourage healthier growth. (See details under "Step 3: Soil Amendments").

Materials already on site:

- Tarp
- Weights (sand and gravel bags filled[6])
- Gator/Tractor for transporting items
- Flame weeder (we did one pass with the flame weeder after temporarily removing the tarp from a quadrant on 8/26/2024, aiming to kill healthy roots before the area was covered again with the tarp for another few weeks). Flame weeding is not a necessary step; we were working with a shorter-than-ideal timeline for tarping, and we thought it might help us catch and eliminate a few germinating weed seedlings.
- Lawn mower, set to lowest mow height setting (the quadrant we dethatched was mowed at a higher level so the dethatcher had something to grab, likely an unnecessary precaution.)
- Compost area for receiving removed turf
- ☑ Cardboard (approximately 900 sq. ft), gathered by volunteers
- Tarps to cover topsoil to protect from rain
- Wobbler sprinkler to wet down the cardboard before putting down topsoil
- Hose/water source to connect to the wobbler sprinkler
- Metal rakes

[5] Calculation: 875 sq ft per quadrant needing topsoil (of which there are 2 quadrants): 1) Method 1: Sod cutter quadrant: [875 sq ft X 0.25 ft (which is 3 inches of soil [or 3/12 foot])]/27 (cubic yard) **= 8.1 cubic yards**; 2) Method 4: Sheet mulching quadrant only needs 2 inches of topsoil so that calculation is: [875 sq ft x 0.166667 ft (or 2 inches of soil [2/12 foot])/27 (cubic yard) **= 5.401 cubic yards.**

[6] E.g. for sandbags: farmersfriend.com/p/sand-bags-100-count?Quantity=100-pack (not an endorsement of the product, merely an example)

Table 1: Four site prep methods

Method 1: Sod cutter, remove turf, add topsoil	Method 2: Black Tarp/Occultation	Method 3: Dethatch/power rake	Method 4: Cardboard, add topsoil
Materials needed: - rented sod cutter, - topsoil (at least 3 inches of topsoil for this quadrant = [875 sq ft (or 25x35) x 0.25 (or 3/12 inch)]/27 (or 3x3x3 for cubic yard) = ~8.1 cubic yards of topsoil - metal rakes - a way/place to remove turf (gator/tractor)	Materials needed: - ~875 sq ft of tarp/solarizing 4-6 mil plastic (can use greenhouse, UV-stable plastic)* - Weights (rocks or bags filled with rocks/sand) Process description: Benjamin Vogt recommends using smothering plastic for four weeks, lifting it off for 1 - 2 weeks to sprout remaining weed seed, and tarping for another two weeks, on and off for a full growing season. Others say that 2 - 5 months of straight application is sufficient. (we tarped from mid-July; to August 27th, lifted the tarp and flame weeded then watered for a week to germinate anything present, then tarped again from Sept. 3-23rd.) *UV stability is EXTREMELY important. If one uses a less stable plastic, it will fragment into bits of plastic and need to be picked up piece by piece.	Materials needed: - rented power rake (we rented a Billy Goat power rake)* -mower -metal rakes Process description: Mow low in spring to weaken the grass during its strongest growth push (mowing low other times and in hot weather will suffice too.) In general, stop supplementing the lawn with water or fertilizer to weaken it. Rent a power rake to dethatch once or twice in the fall (we only had time for once), remove thatch, and seed into the dethatched area in the fall or winter. (Might require extra seed in spring.) We will NOT use the nurse crop in this quadrant since there is already competition and erosion control from the grass roots. *Important note for others renting a power rake: It is possible to rent a power rake with a foldable handlebar which will fit in the back of a small SUV or other vehicle **E.g. Bluebird PR 18 Power Rake.** Approx. cost: $75 for 3 hours - $120 for a day.	Materials needed: - mower to mow low - metal rakes - wobbler sprinkler/hose - 875~ sq ft cardboard - topsoil= at least 2 inches of topsoil for this quadrant = [875 sq ft (or 25x35) x 0.1666667 (or 2/12)]/27 (or 3x3x3 for cubic yard) = ~5.4 cubic yards of topsoil **Note: Please thoroughly wet the cardboard before adding topsoil.** Note: We used LESS topsoil here because we don't want this part of the meadow to be much taller than the other three quadrants.

Figure 1: The quadrant placements

The classroom is here (North)

Method 2: Black tarp	Method 1: Sod cutter (and topsoil)
Method 4: Sheet mulch (cardboard and topsoil)	Method 3: Dethatch/Power rake

The food/plant production field is here (South)

Photographs of the installation day:

Discussion and thoughts on the preparation methods:

There exists no perfect method for converting lawn to meadow when it comes to inputs and their environmental impacts; whether one is using cardboard or plastics (shedding microplastics and introducing other chemicals onto the site), or relying on herbicides, fossil fuels, or purchased topsoil, all methods for lawn to meadow conversion have potential negative effects. Still, these are mostly considered short-term effects and are likely well worth the gains resulting from supporting more native plants, thereby creating habitat and forage for pollinators, other animals, and microorganisms.

Hilltop Hanover Farm (HHF) wanted to select methods that would demonstrate to homeowners[7] and to our community how one might convert a lawn to meadow with native seed, and more specifically, local ecotype seed (see the "Discussion on the seed mix," pages 25-27) without using an herbicide. There are a number of reasons why one might be "pro-herbicide" for such a project. Certainly, many professionals hold that herbicides can be the best approach, given the popular consensus that the types of herbicide (e.g. glyphosate-based herbicides) usually deployed for these projects are largely claimed to have a temporary presence in the landscape, broken down by soil microbes within weeks to months of application. Furthermore, turf killed by herbicide is left in place and serves as an erosion control method for seeding into, allowing the prep team to avoid the more laborious physical manipulation of a site (removing large quantities of dead or living vegetation) and/or longer-term preparation timelines needed for other methods. That said, there is conflicting information about the overall impacts of herbicides, and their breakdown timelines.[8] Furthermore, HHF does not allow herbicide use at the farm, so we wanted to focus on other approaches that might be "doable" for the average homeowner.[9] "Doable" is subjective, and some of the methods we used pose more difficulty than others. For example, while sod removal (Method 1) very reliably eliminates turf, it does require the rental and operation of reasonably heavy machinery, the carting away of a lot of organic matter (the sod), and the introduction of a large volume of new organic matter (the topsoil). Meanwhile, sheet-mulching (Method 4) is also very popular, but, again, one must bring in and spread a large quantity of topsoil. One likely can't know the quality of the topsoil one is purchasing and what weed seeds, if any, might be present therein. Meanwhile, cardboard as the base for the sheet-mulching – largely accepted as a way to create new garden beds – is a contestable material choice since there is little research into the effects of the chemicals in cardboard and how they might impact the environment. Occultation (Method 2) (using an opaque tarp to block the light to the soil and to heat the soil to help kill the existing seed-bed) is frequently cited as a dependable option, but plastics shed microplastic, and large sheets of plastic are expensive and not easily sourced. While generally a very effective way to eliminate existing vegetation, our tarping time at HHF was shorter than is desirable, and we know that our "turf" includes difficult-to-control invasives like Mugwort (Artemisia vulgaris), which can pose an issue for the long-term success of the meadow, and indeed will be a management issue for all quadrants moving forward as Mugwort is a particularly challenging species to keep at bay. **Of the four methods selected, the most**

[7] Homeowner is used as a catch-all term for someone who might be in a position to convert a lawn to meadow in a residential area, but this can, of course, also be done in commercial areas. "Homeowners" is obviously a limited term and is not the only category of person who might want to participate.

[8] See Kiviat, Erik, "Are Herbicides Dangerous?" in the bibliography.

[9] For a review of many of the methods available for a lawn-to-meadow conversion, see the Xerces Society's "Organic Site Preparation for Wildflower Establishment" in the bibliography, which includes a review of seven organic methods of preparation: solarization, smother cropping, sheet mulching, repeated shallow cultivation, soil inversion, organic herbicides, and sod removal.

intriguing to this author, and seemingly "doable," is Dethatching/Power raking (Method 3), which we learned about from Sarah Weaner Cooper of New Directions in the American Landscape and which uses the power rake to dethatch the existing turf prior to seeding. The **"**Plantlife" organization in Salisbury, England has also used a similar preparation. You can learn about it on their "Meadow's Hub" here: https://meadows.plantlife.org.uk/3-maintaining-meadows/managing-meadows-of-all-sizes-with-mowing/ where they have included a wonderful preparation video. This is a less labor intensive and less destructive approach to lawn conversion (see Roach, Margaret and Christopher, Thomas in the bibliography for further details), more akin to haying and overseeding.[10] We found the power rake easier to operate than the sod cutter and, as noted in Table 1, we can suggest a power rake that can fit in an average SUV or hatchback car, making rental more approachable if this specific power rake can be sourced from a local tool-rental shop. HHF used a variation of the Weaner Cooper approach; we did NOT plant landscape plugs, and we did not apply elemental sulfur, which lowers the pH to give competitive advantage to the native plants over the turf grasses by binding up some of the available nutrients and disfavoring the less-nutrient-poor adapted non-natives species. The use of elemental sulfur was not indicated, as the soil pH of the HHF site is already quite acidic. That said, the HHF site is more "difficult" than the average turf-lawn, so we will have to see whether this approach will work for a site with more-than-average invasive pressure. Still, Sarah Weaner Cooper's experiment has been successful to this point on her property, and readers should follow her progress and ours as they make decisions about how to convert their lawns.

As the meadow progresses, we look forward to updating the HHF community.

Noted potential future issues:

- Overall, and assuming the seeds germinate, the main concern for the HHF meadow will be invasive species management, most notably Mugwort. Mugwort is present in the entirety of the surrounding field and was seen growing back in the fall within the previously occulted quadrant and is definitely still growing in the dethatched quadrant as well.

- If seed germination is not terribly successful, there are a few, low-hanging fruit options as to why that might be the case: 1) We did not use a cultipacker or lawn-roller for obtaining seed-to-soil contact, choosing instead to walk on the seedbed after the seed broadcast. It could be that walking was not sufficient. 2) The soil on this site is very compacted; it was difficult to drive in a post more than 4 to 6 inches deep. This could greatly impact the meadow's establishment.

- As you'll see in the "Seeding" section below, we used chaff from previous native seed cleanings as part of the mulch on the meadow. This was sensible in theory, but as the bags of chaff were deposited onto the site, there appeared to be a lot of seed in the bottom of the bags. The late addition of large amounts of single species (two which come to mind are Solidago speciosa and Pycnanthemum muticum) may shift the balance of the meadow drastically. It might also not pose any issue, as the chaff was previously stored in suboptimal conditions in the rafters of a

[10] For those interested, Weaner Cooper is also teaching short online courses through the NDAL website–the next one is November 21, 2024 -https://www.ndal.org/upcoming-events/lawn-to-meadow.

barn with no temperature controls.

- Fall 2024 is experiencing an extreme drought. We don't know if this will affect the seeding, although we have been watering the quadrants post-seeding with a wobbler sprinkler to help the nurse crop to establish.

- Deer: there is no protection from deer on the site (similarly, see the predation note under the "Discussion and thoughts on the seed mix" section, p. 27). After germination, it may be necessary to spray the edges of the meadow with a product such as 'Deer Out' for the first few years of establishment to avoid the seedlings being eaten by deer before establishment.

- Lastly, the Hilltop site is on a septic field. As this is a very large septic field, we were not concerned about tarping a small portion of it. That said, one should research seeding over septic fields if concerns exist about one's own property.

Step 2: Seeding

Deadlines and materials needed:

Fall/dormant seeding: before October 1. (We seeded on September 27th.)

Purchase/acquire by September 23rd:

- ☑ Inert material. We used seven-and-a-half 50 pound bags of play sand. The recommendations for how much inert matter to mix with seed varies.[11] Inert material options include: vermiculite–recommended by Benjamin Vogt; play sand [heavy, but play sand is the chosen inert material for HHF because we have it on site]; rice hulls; cat litter; or sawdust (usually free and a good choice but see potential issue in footnote).[12]
- ☑ Nurse crop: Annual rye (Lolium multiflorum) to be mixed with the native seed mix in the amount of 0.75 lbs (calculations below). Note that we decided NOT to mix the nurse crop with the seeds for the Method 3 quadrant; there is already a lot of competition with the grasses/other plants previously growing in that quadrant. Therefore, we only needed enough nurse crop to seed at 12 lbs/acre for 2,625 sq ft.
- ☑ Inoculant for legume seeds mixed with dampened seed before seeding (inoculant from Prairie Moon is good for one year from opening.)
- ☑ Method for tamping the seed to get good seed-to-soil contact. We used people walking on top of the area, but most projects recommended using a lawn roller/tamper.[13]
- ☑ Chaff or Weed-free Straw: The recommended number of 50-pound-bales per 1000 sq ft varies from source to source, but it is somewhere between 1 to 1.5 bales per 1000 sq ft.[14] We used native plant chaff from previous seed cleanings and two bags of Mainely Mulch

[11] For example, Diboll, p. 354: suggests 1000 sq ft = four 5-gallon buckets. Since this is a 3500 sq ft project, it would have meant using 14 buckets worth of inert material. Note that other sources don't recommend quite this much inert material (some say 2-3 times the amount of seed is sufficient). And others say 8 parts inert material to 1 part seed (e.g. American Meadows).

[12] Sawdust is recommended by Prairie Nursery and by The University of Delaware extension but is NOT recommended by Diboll in his book, who says that sawdust as mulch can rob the soil of nitrogen and retard emergence (Diboll, 354). Univ. Delaware says it "works well because it can be spread evenly and once it is moistened, becomes a good germination medium. Additionally, sawdust serves as a mulch and excludes light, reducing the germination of foxtail and crabgrass—two annual weeds often plaguing new meadows. Use a minimum depth of ½" of sawdust" (see "Successfully Establishing Meadows from Seed in Delaware and the Mid-Atlantic" in Bibliography). Prairie Nursery (which oddly enough is Neil Diboll's company) says: "The sawdust that is used to dilute prairie seed for hand broadcasting has no negative effect on the soil or seedling germination and survival. The amount of sawdust applied during the seeding process is miniscule in comparison to the total soil area covered, and will not cause a problem." (See Diboll "Site Preparation" p. 12).

[13] e.g. There are many options but one is Landzie lawn roller (can be found in google search)

[14] Neal, Cathy "Planting for Pollinators," p. 8 (1 bale to 1000 sq ft); OR Diboll, Neil, "The Gardener's Guide…", p. 354 (1.5 50-pound bales per 1000 sq ft)

(https://lucernefarms.com/mulch-products/). Approximately three bags of Mainely Mulch would have sufficed if we weren't using the chaff.[15]

- ☑ ~~Erosion control blanket or erosion blocking device?(We deemed it unnecessary for this project.)~~
- ☑ Seeds for species not on site:
    - ★ Carex brevior (not ecotype, Ernst) - a low-growing, cool season sedge
    - ★ Fragaria virginiana (local ecotype, Greenbelt) - low-growing, rhizomatous perennial
    - ★ Schizachyrium scoparium (Albany Pine Bush ecotype, Ernst, and using a small amount HHF wild collections)
    - ★ Chamaecrista fasciculata (not ecotype, Greenbelt sent us what they had previously purchased from Ernst) - we wanted a variety of legumes in the seeding
    - ★ Desmodium canadense (PA ecotype, Ernst) - we wanted a variety of legumes
    - ★ Juncus tenuis (local ecotype, Greenbelt) - a cool season, perennial rush, that is lower growing within the meadow canopy.

Materials already on site:

- Buckets: We used eight, 5-gallon buckets to hold our seed/inert material mix and to divide it up by quadrant, and then we had smaller buckets for broadcasting.
- Local ecotype seeds from both farm grown collection and wild collections (seed collection is by permit, and we follow the 'Seeds of Success' collection protocols[16]).
- Large pale or way to mix seed with inert material. We used a mobile swimming pool, but you can mix seed on a heavy tarp or in the back of a gator or pick-up truck.
- Rakes (to remove excess organic matter after dethatching and to smooth soil surface where applicable. Note: Diboll (p. 350) does not recommend raking the seeds into the soil in the fall, because the seeds will work into the soil on their own, but the HHF team raked them in lightly.
- A few more small buckets for separated out legume seed and inoculant and for very small seeds to mix separately with play sand. Small seeds can be buried too deeply with the raking process, so it is better to hand broadcast them after raking so they sit on the surface of the soil.

[15] "Weed-free straw" is a confusing term. Diboll says winter wheat is best ("Site Preparation," p.11). Research led us to the"Mainely Mulch" product, which is a heat-treated, compacted straw for animal beddings that should be relatively free of weed seed and can be sourced at stores like Agway.

[16] See the 'Seeds of Success' protocol information in Bibliography.

Seeding plan:

1. Remove as much stubble and organic matter as possible on sites with preparation that leave any stubble (only relevant to Method 3 above).

2. Mix appropriate inoculant with its corresponding (moistened) legume seed[17], and separately mix inert material with regular seed and **moisten** for dispersal (our play sand was already moistened when we went to mix it with the seed), remember also to separate out very light or small seeds for separate broadcasting. Prairie Moon says most inoculants should be added to moistened seed and broadcast directly. (https://www.prairiemoon.com/inoculum-for-legumes?variant_id=31160)

3. Broadcast: Divide the seed and inert material mix into buckets by quadrant for broadcasting In perpendicular passes over the site. Note also that Diboll and Williams suggest **increasing the seed quantity used in the original mix by 30% when hand broadcasting (we did this)** for a better chance at good seed-to-soil contact. *Use the walking pattern diagram and description on the next page in Figure 2*.

4. For colorful drifts, you can overseed with specific species after the general mix has been sown. (We did NOT do this.)

5. After broadcasting, tamp down with the roller, or go over the area with heavy tractor wheels, NEVER in wet weather because seed will stick to tires and the tires also compact wet soil (Diboll, 350). We just walked over the area a number of times.

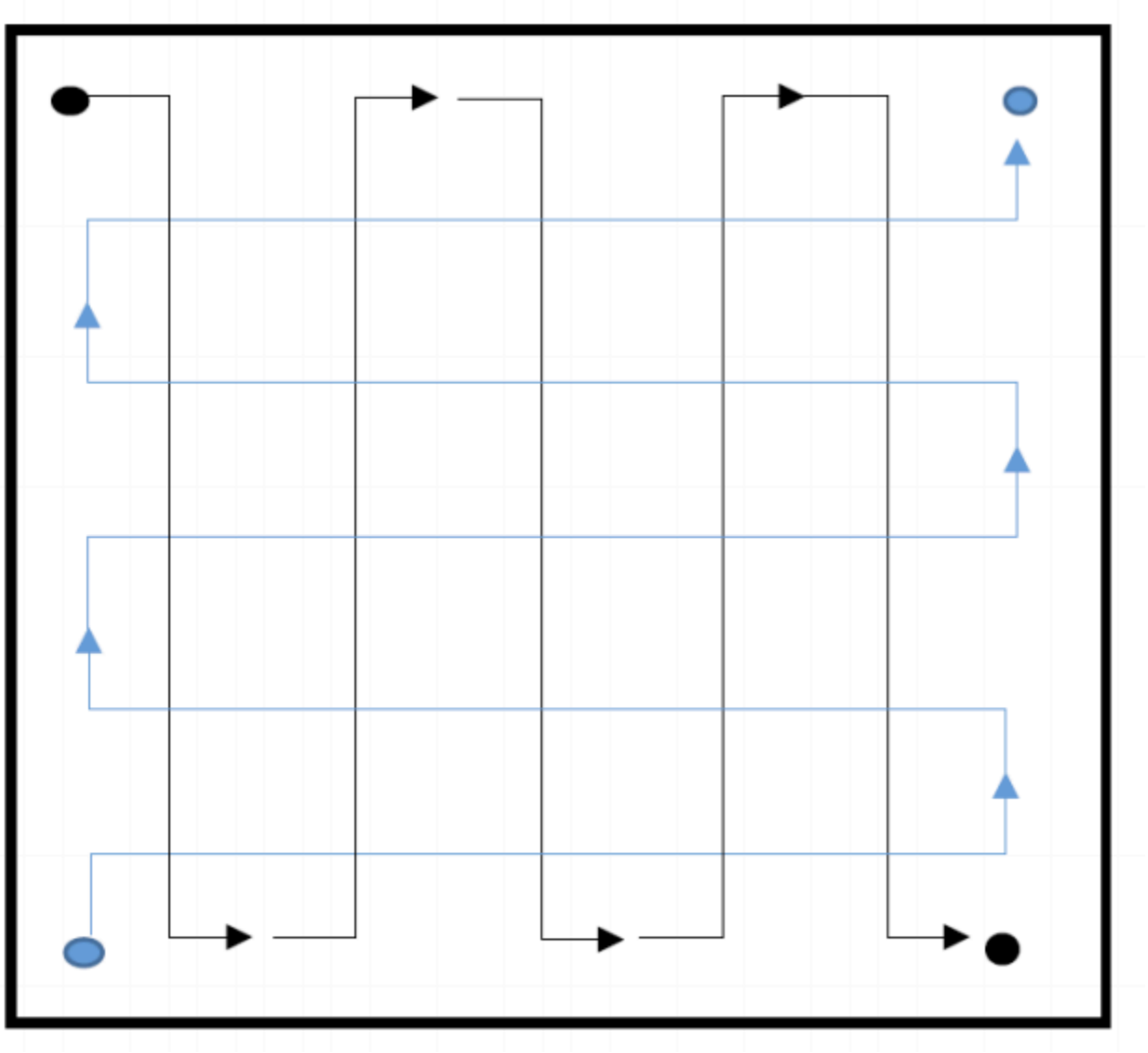
6. Spread seed chaff and ½" to 1 inch of inert straw on top to stop erosion and protect the seeds from predation. Approximately 50% of the soil should be exposed to sunlight when mulching with straw (Weaner, "Garden Revolution," p. 252).

7. Important: **if seeding entirely in the fall season, it is advisable to increase the seeding rate for warm season grasses by at least 50-100%** (Diboll, p. 342-3) since they won't be germinating until the following spring and can be predated upon or blown away in the meantime. Other sources suggest a 50% increase may be sufficient [Williams, p. 1]). Regardless, and for example, if the seed mix contains 20 grass seeds per square foot for a non-dormant seeding, 30 seeds per square foot should be used for a dormant seeding, and if hand broadcasting, then the total number of seeds should 30% higher than that (as per the recommendation in step #3 above), at 39 seeds per sq ft (Williams, p. 1). The team briefly considered putting down our warm season grasses separately from the rest of the mix, that is to sow the warm season grasses in spring, instead of in the fall, but I called Neil Diboll who suggested that this practice wasn't a great idea since weather might make it difficult to get onto the site (if it is exceedingly wet in the spring, for example, this warm season grass seeding could be delayed).

[17] One bag of inoculant from Prairie Moon is good for up to 1 pound of seed.

Figure 2: Walking pattern from University of New Hampshire Extension

(see Neal, Cathy. “Planting for Pollinators” p. 8 in the Bibliography)



When broadcasting seed, divide the total amount of seed in half. Mix the first half with the carrier and spread it as evenly as possible, going back and forth in one direction (following the black lines), then mix and spread the other half in the other direction (blue lines). For large areas, divide the total area into several areas of 400-500 square feet each and spread the seed in each area in this manner to get the most uniform distribution of seed possible.

Photographs of the seed mixing and sowing day:

Seed Selection information:

Research on seed selection and how to design a seed mix:

A) Notes from Larry Weaner's "Garden Revolution" book, Roundtop's "Six Basic Elements for a Successful Native Grass and Forb Establishment," and from Dave Williams' "Designing Seed Mixes":

- A more diverse seeding (and ecotype seed) is always better as studies have shown that as plant diversity goes up, then invasive pressure usually goes down. (Because more niches are filled, and there is less room for weed seeds to germinate.)
- Williams suggests 50:50 grasses/forb. Other books suggest 60:40 (Diboll "Designing Natural Landscapes" also suggests 60:40). E.g.: for 80 seeds per sq ft (60:40 graminoid:forb) = 48 seeds per sq ft of grasses/graminoids:32 seeds per sq ft of forbs
- Sources recommend anywhere from 40-120 seeds per sq ft (Larry Weaner 70-120 seeds per sq. ft [Weaner, "Native Meadow Design Workshop," p. 11]; other sources recommend 40-60 seeds per sq ft [Xerces Society "Establishing Pollinator Meadow from Seed," p. 6]; and Diboll says 80 seeds is a good number.) **We chose 80 seeds per sq ft.**
- A suggested minimum of 6 grasses (including cool season), 3 sedges, 25 forbs (of which 5 legumes, and 20 non-legumes) and the seed mix should include annuals and biennials, not to exceed 10% of the mix (Williams, "Prairie Restoration Series: Designing Seed Mixes").
- Try to equalize the number of seeds per sq ft for each forb if money allows (Williams).
- Nurse crops: use cover crops (like oat [Avena sativa] and rye [Lolium multiflorum]) to mix as a nurse crop with the seed mix at a lower rate than would be used for a cover crop in order to help fill empty soil surface area in the first year or two of growth of the meadow.
- Plant seed at a proper depth of ⅛ to ¼ inch (absolutely not below ¼ or the plants will not germinate), and if you are hand broadcasting, the seed to soil is less predictable*, so you will want to increase the seeding rate by 30%* (Williams).
- Buy seed by PLS (pure live seed) weight and demand current test.[18] And don't buy with a high percentage of inert matter (chaff); it can cause problems if using a seed drill.
- Buy only debearded seed if available (Roundtop)

[18] Pure live seed (PLS): "not all the seeds that a plant produces are viable, and the percentage that is viable varies from species to species (and within the same species year to year). Good seed houses test each species, each year and record viability percentage. E.g. If you need 1 oz of cardinal flower seed, and its tested viability for that year was 50 percent, then a reputable seed house will send 2 oz (which will mean you receive 1 oz of pure live seed)" (Weaner, "Garden Revolution," p.239). Ernst has a good explanation of how to do the conversion on their website here: https://www.ernstseed.com/resources/pure-live-seed/) and PLS is most easily described in Morris Houck's paper cited in the Bibliography. "The basic formula to calculate PLS is: Percent (%) Purity x Percent (%) Total Germination /100 = % PLS" (Houck, p. 3).

B) Notes on seed mixes from "Designing Natural Landscapes: Meadow Design with Native Prairie Seed Mixes" (Diboll/Prairie Nursery; p. 7-8). The entirety of this section is a direct quote (in GREY highlight), as I found this advice extremely useful.

1. A Prairie seed mix should contain a minimum of 40 seeds per sq ft of perennial prairie species (excluding biennials such as Black eyed susan). Rates of 50-80 seeds per sq. ft are even better.

2. Grasses should not exceed 20 seeds per sq ft if a strong component of flowers is desired. When seeding tall prairie grasses, rates as low as 10-15 seeds per sq ft will yield a better floral display.

3. Subtract out the seeding rates for any annuals or biennials (e.g. Partridge pea [Cassia fasciculata], Dotted mint [Monarda punctata], Black-eyed Susan, etc.) from the total seed mix to determine the "Perennial seed rate." It is the perennial plants in the mix that will determine the long-term structure of a prairie plant community. Annuals/Biennials will fade out after the first few years, and will not be long-term members of the mature prairie plant community. (Note: when I spoke with Diboll, he said this rule applies to short-term cool season grasses, such as Elymus canadensis, too.)

4. For a good display of flowers, at least 50% of total seeding rate should be composed of perennial flowers, with 25-50 seeds per sq ft of perennial flowers.

5. The biennial, Black-eyed Susan, can be planted at a rate of 4-10 seeds per sq ft (1.5 to 4 oz per acre) to create a floral display in the second year while the slower-growing perennial grasses and flowers are developing.

6. Smaller-seeded species tend to "get lost in the shuffle" and need to be seeded at significantly higher rates per sq ft than larger seeded species. Species containing more than 50,000 seeds per ounce should be seeded at two to three times the rate of larger seeded species (500-50,000 seeds per ounce) to account for this effect. Species that contain more than 200,000 seeds per ounce can be seeded at three to five times the rate as for larger seeds in terms of seeds per sq ft.

7. Seeding rates should be increased for species that are to be more prominent in the planting. For instance, certain showy plants such as the Blazingstars (Liatris spp.), Pale Purple Coneflowers (Echinacea pallida.), Purple prairie clovers (Dalea purpurea), Asters (Aster spp.), spiderworts, butterfly weed, etc. can be safely seeded at high rates without jeopardizing the development of other species in the planting.

8. With the exception of extremely small-seeded species, no single flowers should be seeded at a rate of more than 5 seeds per sq ft in a diverse prairie mix that contains at least a dozen flowers. Most flowers should be seeded at a rate of 0.5 to 3 seeds per sq ft in a mix that contains 12 to 40 different flower species. Exceptions to this rule include aggressive plants that spread rapidly by seed or by rhizomes, such as Ox Eye Sunflower

(Heliopsis helianthoides), Common milkweed (Asclepias syriaca), and the genus Helianthus. These species should be seeded at very low rates, between 0.10 to 0.25 seeds per sq. ft. Large specimen plants that provide a lot of show per plant, such as members of the genera Baptisia and Silphium should also be seeded at lower rates of 0.25 to .50 seeds per sq ft. Another approach is to spot-seed patches or drifts of specimen plants in designated areas to create the desired effect.

9. When seeding solid stands of prairie grasses, use a rate of 25-50 seeds per sq ft. Some recommended seeding rates for solid stands of grasses are listed below:

Tall prairie grasses seed weight per acre		**Seeds per sq ft.**
Andropogon gerardii	10 PLS lbs per acre	30 seeds per sq ft.
Panicum virgatum	5 PLS lbs. per acre	33 seeds per sq. ft
Sorghastrum nutans	10 PLS lbs per acre	30 seeds per sq. ft.
Short prairie grasses weight per acre		
Bouteloua curtipendula	10 PLS per acre	29 seeds per sq ft
Schizachyrium scoparium	10 PLS per acre	32 seeds per sq ft
Sporobolus heterolepis	10 PLS per acre	51 seeds per sq ft.

10. Certain aggressive species should be planted at rates that should never be exceeded. If planted at too high a rate, these plants may be “too successful,” and out-compete other desirable species. It is critical that the proper balance between species be maintained. Maximum seeding rates for selected aggressive species are listed below. These rates apply to seed mixes that are designed to be balanced between a wide variety of species, with no individual species dominant over the others.

Maximum seeding rates for select aggressive species grasses		
	weight per acre	**seeds per sq ft**
Andropogon gerardii	1.0 PLS lb/acre	3 seeds/sq ft
Panicum virgatum	0.5 PLS lb./acre	3 seeds/sq ft
Flowers		
Agastache foeniculum	2.0 PLS oz/acre	3 seeds/sq. ft
Asclepias syriaca	5.0 PLS oz/acre	0.50 seeds/sq ft
Coreopsis lanceolata	3.5 pls oz/acre	1 seed/sq. ft.
Echinacea purpurea	6.5 PLS oz./acre	1 seed/sq ft.

Helianthus laetiflorus	2.0 PLS oz./acre	0.20 seeds/sq ft
Monarda fistulosa	1.0 PLS oz/acre	2 seeds/sq ft
Ratibida pinnata	4.0 PLS oz/acre	2.5 seeds/sq ft
Rudbeckia hirta	4.0 PLS oz/acre	9 seeds/ sq ft
Rudbeckia subtomentosa	2.0 PLS oz/acre	2 seeds/ sq ft
Rudbeckia triloba	4.0 PLS oz./acre	3 seeds/sq ft

General Relationship Between Pounds Per Acre and Seeds Per Square Foot

As noted previously, most prairie seed mixes are seeded at rates between 5 and 15 PLS pounds per acre. The prairie grasses will typically be seeded at a rate of 4 to 10 PLS pounds per acre, and the flowers at a rate of 1 to 5 PLS pounds per acre. These seeding rates typically translate into grass seeding rates of 15 to 30 seeds per sq ft, and flower seeding rates of 20-100 seeds per sq ft or more, depending upon the exact seeding rate and species composition.

Nurse crop to add to seed mix:

Nurse crop calculations per 875 sq ft quadrant -

- Rye - For Lolium multiflorum best to use 10-12 lbs/acre (Ernst/Prairie Moon), Diboll says on a slope to use 15 lbs/acre (p.343). **We chose to use 12 lbs/acre.**[19]

Calculation: 3 quadrants seeded with the nurse crop (dethatched quadrant NOT seeded with the nurse crop): 2625 sq ft/43560 sq ft= 0.06026171 x 12 lbs/acre = 0.723 lbs or 11.57 oz. of Annual rye (Lolium multiflorium)

While annual rye can overwinter and will need to be cut back to 6" the first year along with any other weedy growth, it will have a better chance of establishing in colder weather and will hopefully serve as a nurse crop in the first year of growth as well, whereas the oats will not come back after the winter (Diboll 343). Regardless, Prairie Nursery/Diboll say that nurse crops should be seeded with meadow seeds no later than Oct. 1st in more northern climates to give the nurse crop a chance to establish.

[19] Note: We had originally planned to use Elymus canadensis (a native, cool-season grass) as the nurse crop. Had we done that, the recommended rate would have been 2-3 pounds per acre or 3500/43560 = 0.08034894 x 3lbs = 0.24 pounds (=3.86 oz) of Elymus canadensis for this planting. Lily called Neil Diboll who said that it is not necessary to add more than the nurse crop amount if using E. canadensis as one of the cool season grass selections. HHF botanist, Lindsey Feinberg, requested we NOT use Elymus canadensis as the nurse because there might be a Founder's Plot of E. canadensis at the farm in future, and we don't want to have the populations intermixing as the E. canadensis we would have sourced for the nurse was non-ecotype.

How to calculate the seed mix:

(Note: one needs to specify "pure live seed" in the order (see footnote #18 for information) if purchasing outside of HHF for seed:)

Two ways to calculate the number of seeds per species:

1. **Larry Weaner calculation** ("Garden Revolution," p. 237)**:**
   AxBxC=D (A: square foot of project; B: number of seeds per sq ft; c: percentage of mix per species; D=# of seeds needed for species)

   e.g. If you want your mix to be 70% joy pye (you wouldn't, this is just for example, but if you did) for a 1000 sq ft plot, then:

   A=1000 sq ft; B=90 seeds/sq ft; C=0.7 (70% of seeded mix) = D (which is 63,000 seeds of joe pye). Joe pye is 95,000 seeds/oz, so 63,000/95,000=0.7 oz of joy pye seed

2. **Benjamin Vogt** ("Prairie Up," p. 103-104)
   You need to know how many seeds are in an ounce of the species you are working with. This information can be found in various places online. Generally, Prairie Moon is a good resource, as the species descriptions include a seeds per oz listing, but one can also use the Seed Information Database, where the information for many species will be listed in an average g per 1000 seed (https://ser-sid.org/). See Appendix C for a calculation to convert from g per 1000 seeds to seeds per oz.

   e.g. Sample calculation for Bouteloua curtipendula, assuming it alone would comprise the warm-season grass percentage (of 35% in this example) of a seeded area.

   50 seeds per sq ft x 0.35 (35 percent [which is the amount of warm season grasses you want in this simplified seeding example]) = 17 seeds per foot.

   17 seeds per foot x 2000 sq ft = 34,000 seed

   34,000 seeds/6,600 seeds per ounce = 5.15 oz of Bouteloua curtipendula

   If we take Vogt's example using Bouteloua curtipendula seeded at 35% of the mix and instead use Weaner's calculation, then:

   A=2000 sq ft; B= 50 seeds per sq ft; C=35% of the mix (0.35); D=35,000 seeds of Bouteloua/6,600 seeds per ounce = 5.3 oz. (Weaner's calculation is slightly more accurate than Vogt's because Vogt used 17 instead of the more accurate 17.5 seeds per sq foot in his calculation. Obviously you can't plant ½ a seed, but you can use the calculation over a large planting.)

Spreadsheets with examples of seed mixes which use the above calculations:

1. Xerces calculator (it's a downloadable file that downloads from this link: http://www.xerces.org/sites/default/files/seed-mix-calculators/PLS-Seed-Mix-Calculator_2020.xls)

2. The present meadow project's spreadsheet is in Appendix D. Excerpts follow on the next page.*

*Please note that I am not a professional spreadsheet creator. I recommend that anyone interested in developing a seed mix, use the spreadsheets and formulas as references to create one's one spreadsheet.

Table 2: Spreadsheet, excerpts regarding the HHF seed mix

SEED SOURCING color key
Forbs- HHF Grown Seed
Forbs and Graminoids - Wild Collections (WC)
Seed sourced outside of HHF
Graminoids - HHF Farm Grown
Seed missing from mix to be added in early spring

SPECIES	PERCENTAGE by weight IN MIX	OZ in Mix
Forbs- HHF Grown Seed		
Asclepias incarnata	0.62%	0.6
Asclepias tuberosa	2.09%	2.7
Doellingeria umbellata	2.12%	0.34
Eutrochium dubium	1.29%	0.17
Monarda fistulosa	2.08%	0.65
Pycnanthemum muticum	1.70%	0.37
Pycnanthemum tenuifolium	2.99%	0.05
Pycnanthemum virginianum	1.74%	0.08
Rudbeckia hirta (biennial)(we added quite a bit, but well under Diboll's recommendation for the limit on seeds/sq ft)	4.15%	0.26 (0.18 clean and 0.08 not cleaned)
Solidago speciosa	3.07%	0.32
Symphyotrichum laeve	2.91%	0.46
Symphyotrichum novae-angliae	1.40%	0.35
Verbena hastata	2.82%	0.24
Vernonia noveboracensis	1.25%	0.52
Zizia aurea	2.49%	2.92
Forbs- Wild Collections (WC)		
Achillea millefolium (added more than original list b/c 2020 source) (WC)	3.74%	0.1 (originally wanted to use less, but this was old seed, so we upped the number)

Asclepias syriaca (WC)	0.19%	0.41
Chamaecrista nictitans (WC) (annual)	0.88%	0.6
Cirsium discolor (just what we had) (WC) (biennial)	0.03%	0.0582
Erigeron pulchellus WC	3.60%	0.1 (not cleaned, included chaff)
Ionactis linariifolia (WC) (oz approximated based on seeds per oz. of New England aster, as seeds per oz. Ionactis not available)	2.49%	0.27 (actually we used 0.47 oz because the seeds were not clean and included chaff)
Lespedeza capitata (WC)	0.82%	0.76
Solidago nemoralis (WC)	1.66%	0.06
Spiraea alba (WC)	3.32%	0.1
Seeds ordered from other sources		
Chamaecrista fasciculata (Greenbelt sent Ernst seeds they had leftover - PA ecotype) (annual)	2.08%	3.74
Carex annectens (cool season)	0.83%	0.16
Carex brevior (cool season) (Ernst not ecotype)	4.61%	0.71
Desmodium canadense (Ernst PA ecotype)	3.22%	2.6
Fragaria virginiana (Greenbelt)	0.91%	0.1
Juncus tenuis (Greenbelt)(cool season)	0.23%	0.021
Graminoids - HHF Farm Grown and WC		
Andropogon gerardii (not enough for the original 7% input request) (WC)	0.83%	1.1
Andropogon virginicus (we did not have it available at seeding time, we may add the 5% Andropogon in the spring)	0%	0.26 (originally wanted to use more [0.39] but not available)
Elymus canadensis (cool season)	0.44%	0.74

(WC)		
Elymus virginicus (cool season)	2.09%	5.247
Eragrostis spectabilis	8.46%	0.3978 (not all of this was clean, so we added more than the original requested amount of 0.2 oz)
Panicum virgatum	0.75%	0.7
Schizachyrium scoparium (Ernst-Albany pinebush) (due to a lack of Andropogon virginicus and little Andropogon gerardii, we upped the percentage of this Schizachyrium from 31.05% to 36% of the graminoid mix (i.e. 18% of overall mix)	14.94%	8.16
Schizachyrium scoparium (estimated weight)(WC)	1.25%	1.95
Sorghastrum nutans	4.42%	6.3
Tridens flavus (WC - used what we had)	5.5%	2.73
Total Forbs % adjusted to 100%	**56%**	
Total graminoids % adjusted to 100%	**44% [of these Graminoids: 81% are warm season and 19% are cool season]**	
TOTALS	**100%**	47.39 oz for seed mix [or 2.96 pounds]

Discussion and thoughts on the seed mix:

Designing a seed mix–particularly a local ecotype seed mix–is challenging and exciting. So many factors impact the selections, including but not limited to: site conditions, seed availability, seed viability (PLS),[20] gregariousness of species, and niches the species fill (seasonal bloom time; lifespan of plant [short or long-lived species]; and the space taken up by the plant above ground [i.e. the overstory, midstory, or understory of the meadow 'canopy'] and below ground [i.e. roots are rhizomatous, corms, tubers, etc.]). Furthermore, another large factor in the decision making process is the designer's educational and preferential biases – "what plants do I know and/or like?" – and general ignorance(s) – "what plants do I not know or what niches have I not accounted for within the meadow due to a lack of information or knowledge?". I chose to call this a reconstruction, rather than a restoration, because I don't believe I have the capacity to put together a seed mix that can truly restore what might have been present at Hilltop Hanover Farm (HHF) – or anywhere else – before disturbance events and/or climate change might have interceded in the natural patterns of the plant communities previously existing here and/or which are demonstrated in more intact landscapes.

An important note about ecoregions and local ecotype seed:

> **Ecoregion:**
> An Ecoregion is an area of environmental similarity based on biological and structural characteristics such as geology, terrain, soil, climate, rainfall, wildlife, agriculture, land use, and plant communities. Ecoregions are organized hierarchically into four levels of increasing specificity, where level I is the most general and level IV is the most detailed. For example, the level I ecoregion for Westchester county is ecoregion 8–Eastern Temperate Forests, and the level IV ecoregion is 59d–Southern New England Coastal Plains and Hills. Hilltop Hanover Farm generally follows level III, which would be ecoregion 59–the Northeastern Coastal Zone.
>
> **Local Ecotype:**
> Local ecotypes are plants of a given species that have evolved in, and are specifically adapted to a defined local ecoregion. Our local ecotype plants are adapted to the high levels of precipitation, and the acidic, sandy soils, and hilly terrain of Westchester. They have coevolved to develop symbiotic relationships with our regional insects, birds, and other wildlife. The ecotypic plants and seeds we grow at the farm are produced with the intent of preserving the high genetic diversity found in wild populations. Genetically diverse plants are more resilient, generating more natural variations which increase adaptability as environmental conditions change.

One of our missions at HHF is to provide Westchester County and the Northeast with local ecotypic seed for restoration efforts. The Northeast has a dearth of such ecotypic seed houses, and therefore, most of the seed used for current restoration projects is sourced from Pennsylvania (from seed houses like Ernst Conservation Seeds,) to the Midwest (from Prairie Nursery, for example), and to the South (from Roundstone Native Seed). Let us "not let perfect be the enemy of the good" is certainly an applicable concept in this situation, yet it is exciting to be a part of a wave of small seed houses introducing a

[20] See footnote 16 on p. 11 for more information on PLS.

stream of ecotypic seed to the market for many of– and more than–the reasons listed above.

Generally, the species we selected can survive in mesic, medium dry, or medium wet soils. The meadow site is very exposed to sun and wind and is on a gentle slope. It is possible the wetter species will not do well, but we had them available, and we have designed a diverse mix of 38 species (made up of our HHF farm grown ecotypic seed, wild collections, and donations from Greenbelt, and purchases from Ernst Conservation Seeds).

The percentages/ounces included in the mix, listed in Table 2 above, will likely look curiously specific to the reader. I certainly found that to be a source of wonderment when reviewing seed mixes in various books and on websites–"why did they choose to include 1.7% of this and 0.6% of that?" I would ask myself. As the reader knows by now, there are many suggested guidelines for designing seed mixes (see my "**Research on seed selection and how to design a seed mix" section)**, and one wants to plan a seed mix which takes into account the various factors mentioned in the first paragraph of this discussion. All of this impacts the selections one might make in order to attempt a meadow reconstruction that can hold up to weed pressure over time, but there is always a level of subjectivity to deciding the percentage each species represents in a mix.[21]

Of course, seed availability and viability also impact the percentages of the mix. Regarding seed availability, we generally worked with what we had at HHF and aimed to include as much ecotypic seed as possible in this mix. That said, if I could have included more Lespedeza capitata or Cirsium discolor, for example, I might have, but I was limited by the farm grown seed and wild collections available, supplemented with the donations from Greenbelt and purchases from Ernst where necessary. I decided to order some species from Ernst and Greenbelt because they were more "essential" species to the success of a meadow. For example, Schizachyrium scoparium frequently makes up the largest percentage of graminoid seed included in a mesic soil meadow mix, but we didn't have enough clean seed on site to meet the percentage I wanted to include. I also wanted to be sure we had enough species to fill up the niches presented in the lower levels of the meadow 'canopy' (like Fragaria virginiana or Carex brevior, for example) and also that we would have enough diversity of legumes and annuals (hence using Chamaecrista fasciculata and Desmodium canadense) and cool-season graminoids (like Juncus tenuis and Carex brevior), so we ordered seed for these species.

Regarding seed viability and pure live seed (PLS), one of the challenges of the project, and which will face future efforts for meadow reconstructions using local ecotype seed, is that small seed houses, like HHF, while working valiantly towards having their farm grown seed tested for the purposes of having PLS numbers to refer to, do not yet generally have these numbers on hand. Therefore, I estimated the PLS at 50% for seeds sourced from HHF or from our wild collections, unless the number was known. A seed mix one purchases from Ernst, for example, will give you all of the PLS numbers and will have already adjusted the mix to account for those values. As more local ecotype seed is grown and available in our area, so too will we have more accurate numbers to rely on for predicting the successful germination of the seeds we sow. For the present meadow, the estimations made may have ramifications for the

[21] For those readers who review Appendix D "Meadow Calculation Spreadsheet," you might notice that the total percentage of seed included in the mix exceeds 100%. I adjusted it back to 100% for representation in Table 2. This does not have an effect on the overall ounces per species included in the mix.

balance of the species growing in the meadow. That takes us back to “not letting perfect be the enemy of the good”; one has to believe that attempting anything is better than giving up due to imperfect conditions.

A few other specific notes about our seeding:

- Lindsey Feinberg, the HHF botanist, originally suggested not to use Panicum virgatum because it is not common in this area of Westchester and is considered more of a coastal species, but we decided to include it when we discovered that we didn’t have a lot of Andropogon gerardii available and had no Andropogon virginicus seed ready for the mix. We did NOT use Solidago sempervirens, although the farm grows it, for the same reason as the Panicum virgatum, since this is a coastal species.

- If one compares the percentages for graminoids to forb above, one sees that we included approximately 53% graminoids (with the intent to add 5% Andropogon virginicus once sourced from field for a total of 58% graminoids) and 67.5% forbs, for a total of ~120.5**%** seeds. Adjusted to 100%, this brings the mix to approximately: 44% graminoids to 56% forb. (If Andropogon virginicus is added in spring 2025, then the seeded amounts would be 46% graminoid to 54% forb.) Experts generally agree that a mix of 60:40 (graminoid:forb) or 50:50 (graminoid:forb) is advisable where a diverse perennial wildflower population is desired to provide forage for pollinators. The final percentages are higher for the forbs than the original goal of 50:50, but some of the forb ounces were deliberately inflated to provide annual/biennial cover in the first year or two of growth, and we expect these species will drop out of the mix over time (this is somewhat true for cool season grasses as well). This relates to the “Perennial seeding rate” mentioned on p. 27 of this document in the selection from Neil Diboll’s article “Designing Natural Landscapes: Meadow Design with Native Prairie Seed Mixes.”

- As noted in the site prep section of this paper, the chaff we put down seemed to have quite a bit of seed still in the bag, so this may impact the meadow balance greatly or not at all.

- Many publications casually mention the expectation that there will be some seed loss due to various factors, such as the inefficiency of hand broadcasting the seed, wind and water erosion, and **seed predation**. They don’t generally give a lot of detail. I wanted to mention that predation of the seed (by birds, chipmunks, slugs [which might eat developing seedlings], and deer) can definitely be an issue. The HHF site benefits from exposure and a resident hawk population, which potentially kept the bird activity to a minimum. But residential lawns might have a larger issue with birds, squirrels, and chipmunks. This will likely require some mitigation after seeding. Various ideas include shiny, moving objects like pinwheels and or applying hot red pepper flakes to the site (while wearing a mask). Some seedings advise to include slug bait or put it down at the time of germination. I have not deeply researched this matter, but did want to mention it as a potential pitfall after the seeding is completed.

Step 3: Soil amendments

Spread soil amendment on the surface of the area the spring (April) after fall seeding.
We decided NOT to spread amendments in the fall, as potassium is so readily leached out of an area and any that would be uptaken would likely be consumed by the nurse crop, which is not ideal. It would be better to add the potassium fertilizer in the spring when it can be available to the germinating native seedlings.

It could be the team will decide NOT to use the fertilizer in the spring. Certainly, the use of fertilizer is not clearly necessary per the discussion:

Discussion and thoughts on soil amendments:

In general, the use of fertilizer–especially inorganic fertilizer–is questionable at best and largely considered unnecessary for meadow establishment given that most of our native meadow species are adapted to low fertility environments and this extra fertilization might favor the vegetative growth of weeds over the native plants. That said, the HHF soil test (see Appendix A "Soil test") showed "below optimum" levels of potassium. I called the UConn Soil nutrient analysis station and spoke with Dawn there about the HHF soil test. Soil nutrient analyses generally make recommendations tailored to crop growth, not native meadow growth. Dawn suggested that 157 lbs/acre for the potassium *should* be sufficient for meadow plant growth, so we do NOT absolutely need to amend, although, again, the K levels are considered "below optimum" (see Appendix A "Soil test") for lawns and food crops. The concern is that, since potassium is an essential nutrient for plant growth, the potassium levels being too low might hinder the native plant growth and establishment of the meadow. As mentioned above, amending soil is not normally recommended for meadow seedings. However, I suggest we amend per the recommendations of the UConn soil nutrient lab report, as the amounts they are suggesting we add are not extreme and will bring the potassium in our soils to a reasonable lbs/acre (or parts per million [ppm]) which will hopefully aid with the healthy establishment of the native species seedlings. If we decide NOT to use the fertilizer in the spring, the native seedlings might benefit from a small amount of the organic matter thatch from the first mowing being left to decompose on site, but this is also not strictly necessary and one can examine the health of developing seedlings to make decisions in the moment.

Regardless of the decision to amend or not to amend, I did some calculations to determine how much the rates from UConn might impact the HHF soil on site. Please find that information in Appendix B "Soil Amendment Calculations" at the end of this document.

Numerous sources suggest that adding potassium might benefit meadow establishment:

1. Kaspari, Michael. "Potassium as a Game Changer in Prairie Food Webs." December 24, 2022. https://michaelkaspari.org/2022/12/24/potassium-as-a-game-changer-in-prairie-food-webs/

note: (less relevant here since we mainly want the Potassium at the beginning to encourage establishment from the seeding but nonetheless interesting.)

2. Diboll and Cox, p. 23:

> "Fertilization is rarely required for proper growth of prairie plants, with the exception of two primary nutrients, phosphorus (P) and potassium (K), and the secondary nutrients calcium (Ca) and magnesium (Mg).…
>
> Plants consume potassium (K) in large quantities, and it is readily leached from soil. Soils low in potassium can be amended using organic sources such as wood ash (0-0-6) or greensand (0-0-17). Readily available forms of inorganic potassium include muriate of potash (0-0-60) and K-Mag, a naturally occurring mineral (0-0-22, with 10% magnesium and 21% sulfur).
>
> Fertilizing and liming creates proper conditions for germination and growth of prairie plants. For best results, lime and organic fertilizers should be incorporated into the top 6 inches of soil. **Inorganic fertilizers can be spread on the soil surface.** Once established, further fertilization should not be necessary, provided that appropriate plants were selected to match soil conditions."
> (emphasis by color added)

3. Clif Little: "Fertility Management of Meadows" (note: Dawn of UConn pointed out that Ohio has very different soil from Westchester, so these numbers are probably not terribly applicable to Westchester; Ohio generally has very heavy clay soils, and we have sandier ones.):

> "Major losses of soil potassium are through forage removal and leaching. The critical soil test levels for potassium are 125-200 ppm (*see below for more info on ppm vs. lbs/acre)*. Plants have the ability to take up more potassium than they need.
>
> The most common source of potassium fertilizer is muriate of potash or potassium chloride (0-0-60). It is a readily available source of potassium. Muriate of potash does have a relatively high salt index, which at high rates can cause salt injury to the crop. Ohio State University fertilizer recommendations limit muriate of potash applications to 300 pounds per acre in a year.
>
> Applications of phosphorus and potassium should be made prior to establishing a new seeding and applied according to soil test results. For maintenance, phosphorus and potassium can be applied at any time during the growing season when soil test levels are above the critical level. However, research shows that if one application of phosphorus and potassium is being done, then fall is the best time for the application. By applying phosphorus and potassium in September or October, plants develop a healthier root system and improve winter survival. This results in a plant better able to withstand drought the following year."

4. Bamert Seed research: https://bamertseed.com/the-role-of-phosphorus-amp-potassium-in-native-prairie-restoration/

Step 4: Post seeding management plan

The meadow will require careful management in the first few years of establishment and while management will simplify in the years following, the meadow will always need to be monitored for invasive plants and weeds.

Watering?:

- Unless there are drought conditions, it is usually unnecessary to apply water to the seedbed of a dormant seeding. After seedling germination, if there is a drought, supplemental water is recommended. (Xerces Society "Establishing Pollinator Meadow from Seed," p.9) In a drought, deeply water the establishing meadow (2-3 hours) every 1-2 weeks (Vogt: 83)

Please note that the management plan for the quadrant using Method 3 (Dethatch/Power rake) will be slightly different in the first year or two of growth and will be written under each Year's management plan in PURPLE text.

Management plan:

(Adapted from three books: Larry Weaner "Garden Revolution" (pps. 246 -248); Neil Diboll "The Gardener's Guide to Prairie Plants" (356-369); and Basil Camu "From Wasteland to Wonder" (pps 159-163)

Main goals of the early years' management:

1. Stop weeds from producing seed
2. Make sure native plant seedlings receive enough sunlight in the first 1-2 years of growth

Year 1 growing season after dormant seeding –

Mowing: Mow at the beginning of the growing season (only if the soil is DRY–never mow when wet) using a flail mower[22] and ideally, this mower has a bag on the side to catch debris to reduce thatch (the layers of cut vegetation left after the mow). If there is no bag, and there is a lot of thatch, this should be blown off of the meadow or gently raked out and composted. Mow every 3-4 weeks to 6" (or whenever the growth reaches approximately 8-10" in height). This will also cut back the nurse crop, which should NOT be allowed to go to seed anyway. If the native seedlings grow taller than 4-6", increase mow height or begin using string trimmers instead of a mower to cut above the seedlings. Allow native plant seedlings to grow as tall as they can before

[22] A flail mower is recommended by Diboll: a "flail type mower works best, as it chops up weeds and prevents clippings from smothering small prairie seedlings. Rotary mowers and sickle bar mowers are okay, but they often leave clumps of cut material which can smother seedlings. Rotary mowers can be problematic, as wet mowed material tends to accumulate on the mower housing and be left in thick clumps. String trimmers are excellent at cutting back weeds on smaller plantings" (Diboll, "The Gardener's Guide to Prairie Plants," p. 357).

the next dormant season, as more mass helps to protect them as they overwinter. It's also okay to leave stubble standing to winter-protect the seedlings.

- Important note: If rain prevents regular enough mowing and weeds grow beyond 12-inch height, after the soil dries, mowing should be split into two separate phases. The first mow should cut the weeds to half their height. Allow mowed material to dry out and mow a second time at the 6-inch level. it prevents seedlings from being smothered by fallen cuttings (Diboll, 357).

Method 3 Dethatch/Power rake management: Mow the same as the other quadrants, but then return with a string trimmer to this quadrant to cut back grassy patches almost to the soil wherever they seem healthy. Do this BEFORE the native seedlings have germinated. Then continue to maintain with the mowing regimen mentioned above so that the grass is continually cut back as low as is possible without nipping the tops of the native plant seedlings.

Weed monitoring: Monitor for weeds (mugwort and crabgrass, for example) (especially from May through July and September, or as needed). Remove weeds by hand with scythe or clippers (not from roots so as to avoid disturbing seedlings and soil bed). Weed pressure is likely to be greater along the edges of the meadow where it meets the lawn. It might be good to cut more frequently up to 1 ft into the meadow along the edges in the first year or two of growth to keep weed seed at bay where they are more frequently blown in or brought in by rain events.

Dormant season after first season of growth: Depending on how the meadow is looking, HHF might consider overseeding using the same steps from the "Seedling Plan" above (assembling the same or similar seed mix sans the nurse crop, mixing that with the inert material, inoculant, etc.). This might bolster the meadow community.

Year 2 growing season –

Mowing: Information from Diboll p. 359: "In the mid spring of the second year, the planting should be mowed close to the ground after the cool-season weeds have initiated growth but before warm-season prairie plants emerge (when buds of the Sugar Maple are breaking open, then rake off the debris. The mid spring mow encourages soil warming which helps stimulate the native plants to grow. In late spring or early summer, one should mow to 12 inches to control biennial weeds (plants that spent the previous year developing taproots, such as Burdock)". Diboll notes "young prairie seedlings seldom exceed 1 foot high before summer of the second year and should not be harmed by mowing," so you can mow to a height of 12 inches without worrying. Biennial weeds (e.g. Burdock, Wild Parsnip, Queen Anne's lace) need to be monitored and if problematic, another mowing after the weeds have been through their most active growth period and are producing flowers (usually there is the first growth period early-to-mid summer and another one in late-summer). In other words, it should help manage them, should there be a second push from the biennials, to mow again to 12 inches. These weeds should NEVER be allowed to set seed. If any seed is set, the weeds should be cut, bagged, and removed as seeds can continue to ripen after the plant is mown down. This year we expect the meadow to be dominated by Rudbeckia hirta and other native biennials.

Method 3 Dethatch/Power rake management: In the early spring, before the first big mow, go through the quadrant with the string trimmer and cut back any grassy patches that look healthy, almost to the ground. Do this early so the native plants will not yet be growing back for the season. Then continue management as written above for year 2.

Weed monitoring: Monitor for weeds (see images in Figure 2 for Mugwort, Queen anne's lace, crabgrass, burdock, for example), especially from May through July and September, or as needed. Remove weeds by hand with scythe or clippers (not from roots so as to avoid disturbing seedlings and soil bed). Certain weeds may be removed by pulling from the soil, but only if this is done carefully (don't try to remove taproot species (like burdock) from the soil as it will cause a great disturbance and likely be unsuccessful).

Figure 2: Weed seedlings examples

Mugwort:	Queen anne's lace:	Crabgrass:	Burdock:
 photo source: https://plantevaernonline.dlbr.dk/cp/graphics/Name.asp?Language=en&TaskID=1&NameID=5	 photo source: https://www.minnesotawildflowers.info/flower/queen-annes-lace	 photo source: https://www.garden-counselor-lawn-care.com/crabgrass-pictures.html	 photo source: https://www.theselfsufficienthomeacre.com/2013/05/foraging-for-burdock.html

Year 3 growing season –

Mowing: By now, if the meadow establishment is moving towards success, meadow plants should have dominance on the site so management becomes less demanding. One can do a burn or an early spring mow in this year, raking off the debris. If cool season grasses become a problem in the future, spring mowing twice (once in May and once in June) may be necessary to rebalance towards the warm season grasses. In other words, you effectively revert to year 2's maintenance plan for this third growing season and then do year 3's maintenance in year 4.

Method 3 Dethatch/Power rake management: If the grass continues to grow back in the spring, go after it again with the string trimmer, cutting it very early and very low, as best you can. The goal is to continue to weaken the old "lawn." Continue maintaining as recommended above for year 3 regardless. One can expect extra weed monitoring in this quadrant.

Weed monitoring: It never hurts to remain vigilant. Continue to cut out weeds by hand as you find them and especially, to remove any set seed.

Ensuing years –

One needs to consider what is being managed for: nesting birds or pollinators, for some examples, but turtles could be an issue too for many sites. This will impact what time of year the meadow is mown down, whether in the late fall (after nesting birds have fledged [although this is still problematic for raptors] and which will eliminate overwintering habitat for pollinators) or mid spring (which will definitely impact nesting bird habitat but will allow the pollinators to spend the winter safely protected by the meadow stubble). Consider mowing different sections at different times to provide diverse habitat for pollinators overwintering or for birds nesting and perhaps in the future the quadrants can be mown on alternating years to some extent. **It would be good to put this in a group calendar.**

No single area should be mowed or burnt more frequently than every two years at this point. "Untreated patches help to ensure repopulation of pollinators." (Xerces. "Establishing Pollinator Meadow…." p.10).

Other management notes:

- If the warm season grasses become too dominant over time, it is possible to knock them back some with a midsummer mow, timed to cut them in their most active growth period. Diboll suggests mowing to a height lower than 12 inches as they send up their flower stalks. This can be done every other year to give the earlier-blooming forbs and cool-season grasses greater presence in the meadow (Diboll 360-361).
- If difficult weeds persist, read Diboll's pages 362-369 for more ideas.
- A nice note from Larry Weaner: It's good to cut down the edges of the meadow plants by 2/3rds (Chelsea chop) in order to have better light infiltration at the edges and to have a better view into the meadow itself for visitors.
- Any time you mow, it's good to remove the organic matter of the thatch. Meadows and prairies developed along with grazing animals like bison and deer, so it is good to remove organic matter from time to time to keep the nutrient inputs under control.
- After many years, reseeding with certain species may add more diversity again.
- One can also remove seed heads from more gregarious native species to slow their progress.
- For more information on weeds, see https://extension.umd.edu/resource/manage-weeds-without-chemicals-maryland/.

Appendix A: Soil test

UConn Soil Nutrient Analysis Laboratory
6 Sherman Place, Union Cottage, Unit 5102
Storrs, CT 06269-5102
860-486-4274
soiltesting.cahnr.uconn.edu

UCONN
COLLEGE OF AGRICULTURE, HEALTH AND NATURAL RESOURCES
EXTENSION & PLANT SCIENCE AND LANDSCAPE ARCHITECTURE

Soil Test Report

Order Number: 22514

Prepared For:
Adam Choper
1271 Hanover St
Yorktown Heights, NY 10598

farmdirector@hilltophanoverfarm.org
732.221.8894

Sample Information:
Sample Name: Future Meado
Lab Number: 5711
Area Sampled:
Received: 7/24/2024
Reported: 8/2/2024

Results

Nutrients Extracted From Your Soil (Modified Morgan)

		Below Optimum	Optimum	Above Optimum	Excessive*
Calcium	**1745 lbs/acre**				
Magnesium	**224 lbs/acre**				
Phosphorus	**14 lbs/acre**				
Potassium	**157 lbs/acre**				

**** Excessive only defined for Phosphorus (>40 lbs/acre)***

Soil pH (1:1, H2O)	5.8
Est. Cation Exch. Capacity (meq/100g soil)	8.0
Buffered pH (Mod. Mehlich)	6.3

Base Saturation	***%***	***Suggested***
Potassium	3	2.0 - 7.0
Magnesium	11	10 - 30
Calcium	55	40 - 50

Element	***ppm***	***Soil Range in CT***
Boron (B)	0.0	0.1 - 2.0
Copper (Cu)	0.1	0.3 - 0.8
Iron (Fe)	3.6	1.0 - 40.0
Manganese (Mn)	3.5	3.0 - 20.0
Zinc (Zn)	1.8	0.1 - 70.0
Sulfur (S)	25.9	10 - 100
Aluminum (Al)	36.5	10 - 300
Est. Total Lead (Pb)	low	

Limestone & Fertilizer Recommendations for Wildflowers

Limestone (Target pH of 5.3)

0 lbs / 100 sq ft

Comments:
LIMESTONE:
No limestone is necessary
FERTILIZER:
Soil test levels for POTASSIUM are BELOW OPTIMUM.

Incorporate per 100 sq ft, 1 lb (2 cups) of 10-10-10 PLUS 0.5 lb (1 cup) of 0-0-60 (potash) OR 1.5 lbs (2 cups) 0-0-22 (sul-po-mag). the equivalent from other sources. See Section III on the Suggested Fertilizer Recommendations for Flowers fact sheet for instructions on when and how often to apply the fertilizer recommended above.

If you have questions about this report or fertilizer recommendations, contact the UConn Soil Nutrient Analysis Lab at (860) 486-4274 or email soiltest@uconn.edu.

If you have questions about any other plant, pest or disease problems, contact the UConn HOME and GARDEN EDUCATION CENTER, Dept. of Plant Science and Landscape Architecture. Phone: (877) 486-6271; email:ladybug@uconn.edu; website:www.homegarden.cahnr.uconn.edu.

Limestone & Fertilizer Recommendations for Flowers (Annuals, Perennials, Bulbs) & Ornamental Grasses

Limestone (Target pH of 6.5)

5 lbs / 100 sq ft

Comments:
LIMESTONE:
Apply ground limestone as recommended to raise the soil pH. For new plantings, work the entire amount into the top 6 to 8 inches of soil before planting. For established beds, gently scratch in limestone into soil around plants. If more than 10 lbs of limestone per 100 sq. ft. is recommended, put one-half down now and the other half in a month or more.
FERTILIZER:
Soil test levels for POTASSIUM are BELOW optimum.

Incorporate per 100 sq ft, 2 lbs (4 cups) of 10-10-10 PLUS 0.5 lb (1 cup) of 0-0-60 (potash) OR 1.5 lbs (2 cups) of 0-0-22 (sul-po-mag) the equivalent from other sources See Section III on the SUGGESTED FERTILIZER PRACTICES for FLOWERS fact sheet for instructions on when and how often to apply the fertilizer recommended above.

If you have questions about this report or fertilizer recommendations, contact the UConn Soil Nutrient Analysis Lab at (860) 486-4274 or email soiltest@uconn.edu.

If you have questions about any other plant, pest or disease problems, contact the UConn HOME and GARDEN EDUCATION CENTER, Dept. of Plant Science and Landscape Architecture. Phone: (877) 486-6271; email:ladybug@uconn.edu; website:www.homegarden.cahnr.uconn.edu.

References (Crop Related):

Soil Test Interpretation and Recommendations	https://soiltesting.cahnr.uconn.edu/wp-content/uploads/sites/3514/2022/06/Standard-Nutrient-Analysis.pdf
Suggested Fertilizer Practices for Flowers	https://soiltesting.cahnr.uconn.edu/wp-content/uploads/sites/3514/2022/06/Flowers.pdf
Fertilizer Conversions & Garden Measurements	https://soiltesting.cahnr.uconn.edu/wp-content/uploads/sites/3514/2022/06/Fertilizer-Conversions-Garden-Measurements.pdf

UCONN | COLLEGE OF AGRICULTURE, HEALTH AND NATURAL RESOURCES

PLANT SCIENCE AND LANDSCAPE ARCHITECTURE

RESULTS REPORT

August 2, 2024

Name: Adam Chopper
Hilltop Hanover Farm
1271 Hanover Street
Yorktown Heights, NY 10598

Order Number: **22514**

Lab Number: MA24-268

Sample Name: Future Native Meadow

Textural Analysis
Percentages are based on the Fine Earth Fraction (Less than 2mm)

Sand:	74.2 %
Silt:	19.6 %
Clay:	6.2 %

According to USDA criteria, this sample classifies as a **SANDY LOAM**. Classification is based on particles that are sand size or finer (i.e. Less than 2 millimeters in diameter.)

Organic Matter
The organic matter as determined by loss on ignition is 3.3 %

University of Connecticut Soil Nutrient Analysis Laboratory

6 Sherman Place Unit 5102 Storrs, CT 06269-5102

Tel: (860) 486-4274 Fax: (860) 486-4562 Web: www.soiltest.uconn.edu

Appendix B: Soil Amendment Calculations

Calculation to determine the rates recommended by UConn are not extreme:

> **Important note:** The following calculations MAY be incorrect. I did these calculations in an attempt to determine how MUCH potassium (lbs/acre) UConn was encouraging us to add to the soil to get an "optimum level." It was more of a thought experiment than anything else.

We will use two inorganic potassium fertilizers recommended by UConn at the following rates:

- 35 lbs of 10-10-10 fertilizer and
- 17.5 lbs of 0-0-60 (muriate of potash, aka potassium chloride)

Our potassium level was calculated to 157 pounds/acre by UConn Soil Nutrient Analysis Laboratory. Converting that to parts per million (ppm) requires multiplying by 0.5.[23] And going the other direction, converting from ppm to lbs/acre requires multiplying by 2.

157 lbs/acre x0.5 = **78.5 ppm is our current potassium level**

In the "Fertility Management of Meadows" (Ohio State University's aforementioned article), the critical amount of potassium that should be available is offered as two rates:

1. Either between 150-200 ppm or
2. By understanding the exchangeable K which is found using the below calculation. Either way, it appears that it cannot hurt the project to amend the potassium.[24]

Exchangeable K	The critical level for ppm K = 75 + (2.5 x Cation Exch Capacity) for all crops.

The HHF soil test said the Cation Exchange Capacity (CEC) was **8** for this field.

So using the Ohio State calculation:

75 + (2.5 x 8) = 95 ppm (which is slightly higher than the 78.5 ppm calculated from 157 lbs/acre).

Now – How to determine approx. how much higher the potassium levels will be after we add the amendments recommended by UConn?

Formulas taken from: Hannan: "Interpreting Soil Reports" in the Bibliography.

"To calculate how much potassium to apply to the soil, subtract the value from the soil fertility report from the optimum rate you've determined you want."

[23] How to Convert Pounds per Acre to Parts per Million.The formula lbs/acre = ppm x 2 can be used to convert between the two numbers. Or lbs/acre x 0.5 = ppm See: Hannan, Joe. "Interpreting Soil Reports."

[24] Dawn at UConn notes that we don't have to amend this soil, since the number of 157 lbs/acre is not terrible. She said you could also do the project without amending and then if you feel you need to add potassium later based on how the plants are growing you could.

In other words, if we want to have approximately 190 lbs/acre (or 95 ppm = 75 + [2.5x8 CEC] x 2) and the soil test report says we have 157 lbs/acre, then we need to add a total of 190-157 = 33 lbs/acre to get to the desired amount of potassium in the soil.

We only need to fertilize 3500 sq. ft, so we use this calculation:

$$\frac{\text{33 lbs/acre need}}{\text{43560 sq ft}} = \frac{X}{\text{3500 sq ft.}}$$

solving for x, we need to add 2.65 lbs potassium over 3500 sq ft.

"The next step is the complicated part. A bag of fertilizer states nutrient values as N-P-K but in actuality it is %N–%P2O5–%K2O. For example, a bag of 10-10-10 fertilizer is 10%N, 10% P2O5, and 10% K2O by weight. A conversion factor of 0.44 is required to convert P2O5 to P and a conversion factor of 0.83 to convert K2O to K. No conversion factor is necessary for nitrogen.

"The following formulas will help you calculate lbs of P or K, which are color-coded to the following example."

$$X \text{ lbs } P \text{ per } \textit{unit weight of bag} = \textit{unit weight of bag} \times \%P2O5 \times 0.44$$

$$X \text{ lbs } K \text{ per } \textit{unit weight of bag} = \textit{unit weight of bag} \times \%K2O \times 0.83$$

Thus, a 50 lbs bag of 10-10-10 has:

- **5** lbs of nitrogen per **50 lbs bag** = **50** x 0.1
- **2.2** lbs of phosphorus per **50 lbs bag** = **50** x **0.1** x **0.44**
- **4.2** lbs of potassium per **50 lbs bag** = **50** x **0.1** x **0.83**

So, if we need to apply 3.0 lbs of potassium to the 6 rows of tomatoes in a 4ft wide band, how much 10-10-10 fertilizer must we apply? There are a couple ways to solve this, the following two formulas derive the same result."

$$\frac{3}{\left(\frac{4.2}{50}\right)} = 36 \textit{ lbs of } 10-10-10$$

or

$$\frac{\frac{3}{.1}}{.83} = 36 \textit{ lbs of } 10-10-10$$

For HHF, using the same calculations and a 50-lb bag of 10-10-10, here is what HHF would need:

2.65 lbs
—------- = 31.55 lbs of 10-10-10 over 3500 sq ft
(4.2/50)

So adding 31.55 lbs of 10-10-10, effectively gets us to 190 lbs/acre of potassium.
…

BUT Uconn is recommending more than that, at the rate of: **35 lbs of 10-10-10 over 3500 sq ft PLUS 17.5 lbs of 0-0-60**

So…reversing the calculation, we can determine the lbs/acre added before determining the 10-10-10.

X
(—-----) = 35 lbs of 10-10-10 over 3500 sq ft
(4.2/50)

this amounts to:

X = **2.94 lbs of potassium added per 3500 sq ft (remember I initially calculated 2.65 lbs).** AND we still need to do the calculation for the 17.5 lbs of 0-0-60 muriate of potash.

Uconn's recommended rate for 10-10-10 will ultimately add 36.6 lbs/acre of potassium

X/acre need = 2.94 lbs (of potassium over 3500 sq ft) = 36.6 lbs/acre potassium added
_____ _____
43560 sq ft 3500 sq ft.

IN ADDITION TO:

0-0-60 is 60% k20 so to get the amount to use the conversion would be:

X Lbs of potassium per 50 lb bag of potash = 50 lb bag x 0.6 x .83 (to convert k20 to K)= There are 24.9 lbs of potassium in a 50 pound bag:

X
—------ = 17.5lbs for 3500 sq ft so 17.5*0.498 = **8.715 lbs of potassium added per 3500 sq ft**
24.9/50

So the 0-0-60 calculation will add how many lbs/acre of potassium?:

X/acre need = 8.715 lbs (of potassium over 3500 sq ft) = 108.5 lbs/acre potassium added
_____ _____
43560 sq ft 3500 sq ft.

UConn is recommending a total of 145.1 lbs/acre (108.5 +36.6) be added to raise the current potassium level of 157 lbs/acre.

145.1 +157 = 302.01 lbs/acre of potassium x .5 = 151 ppm (recall that Ohio State said critical levels of potassium are between 125-200 ppm)

Conclusion:

In the end, it does not appear problematic to go with the UConn recommendation for adding both muriate of potash (10-10-10) and 0-0-60.

Appendix C: Calculation to convert "grams per 1000 seeds" to "seeds per ounce"

If Prairie Moon does not have the species' seeds per ounce listed on their website, then the information might be found on the Seed Information Database (https://ser-sid.org/), which will list grams per 1000 seeds of the species.

Example 1: Chamaecrista nictitans

1000 seeds = 2.2 grams

If 2.2 grams = 0.0776027 ounces

Then 1000 seeds = 0.0776027 oz

To determine how many seeds are in 1 oz

$$\frac{1}{0.0776027} = \frac{X}{1000}$$

Solving for X=12,886 seeds per oz

Example 2: Lespedeza hirta

1000 seeds = 3.229 grams
3.229 g = 0.114 oz
1000 seeds = 0.114 oz

$$\frac{1}{0.114} = \frac{X}{1000}$$

X = 8,772 seeds

Appendix D: Meadow Calculation Spreadsheet

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O
2		A= sq.ft	B= seeds/sq.ft	% of forb/grass (50:50)	C= % of total mix (decimal %) (i.e. take 50% of forb number to the left) (e.g. Cell E7...sum=(D7*0.5)/100)	D= Seeds/oz (fixed for each species)	E=Seeds per sq ft (e.g. cell G7...sum=E7*C7)	Larry Weaner calculation: Total oz of seed in mix based on 100% PLS ((AxB)xC)/D (e.g. Cell H7...sum=(B7*C7)*E7/F7)	Vogt calculation: Total oz of seed in mix based on 100%PLS (A*E)/D (e.g. cell I7...sum=(B7*G7)/F7)	price/oz in $	total pricing Ix J	True PLS % (based on seed testing and taken from Northeast Seed Collective website) (cells with the no. 50 in them is a guess at 50% germination rate)	**total oz of seed based on true pls% (using Vogt calculation so that the 50% increase in warm season grasses is captured here) (e.g. cell M7...sum=(100/L7)*I7)**	**total oz of seed based on true pls% x 30% (1.3) increase to account for handbroadcasting (e.g. cell N7...sum=M7*1.3)**	notes
3	Note: wetter species marked in blue														
4	Note: Greenbelt species marked in green														
5	Note: Ernst species marked in purple														
6	Note: Wild collections (WC) marked in red														
7	**Forbs- Farm Grown Seed**														
8	Asclepias incarnata (2022 clean; 2023 not clean)	3500	80	1.49	0.00745	4800	0.596	0.435	0.435	15	9.02	94	0.462	0.60	
9	*Asclepias tuberosa*	3500	80	5.04	0.0252	4300	2.016	1.641	1.641	20	54.01	79	2.077	2.70	
10	*Doellingeria umbellata*	3500	80	5.1	0.0255	55000	2.04	0.130	0.130	40	13.50	50	0.260	0.34	
11	*Eutrochium dubium*	3500	80	3.1	0.0155	80000	1.24	0.054	0.054	25	4.20	42	0.129	0.17	
12	*Ionactis linariifolius (Wild collection) (oz approx. based on NE aster)*	3500	80	6	0.03	80,000	2.4	0.105	0.105	30	8.19	50	0.210	0.27	actual amount .47 oz, doubled b/c not cleaned
13	*Monarda fistulosa*	3500	80	5	0.025	70,000	2	0.100	0.100	15	9.75	20	0.500	0.65	
14	*Pycnanthemum muticum*	3500	80	4.1	0.0205	120000	1.64	0.048	0.048	40	14.63	17	0.281	0.37	
15	*Pycnanthemum tenuifolium*	3500	80	7.2	0.036	300000	2.88	0.034	0.034	40	2.16	81	0.041	0.05	
16	*Pycnanthemum virginianum*	3500	80	4.2	0.021	200000	1.68	0.029	0.029	30	2.29	50	0.059	0.08	
17	*Rudbeckia hirta (biennial)(added quite a bit, but under Diboll recommendation for limit on seeds/sq ft)*	3500	80	10.8	0.054	92000	4.32	0.164	0.164	10	2.61	82	0.200	0.26	0.18 clean and .08 not clean
18	*Solidago speciosa*	3500	80	7.4	0.037	75000	2.96	0.138	0.138	30	9.45	57	0.242	0.32	
19	*Symphyotrichum laeve*	3500	80	7	0.035	55000	2.8	0.178	0.178	30	13.90	50	0.356	0.46	
20	*Symphyotrichum novae-angliae*	3500	80	3.4	0.017	80000	1.36	0.060	0.060	25	8.79	22	0.270	0.35	
21	*Verbena hastata*	3500	80	6.8	0.034	93000	2.72	0.102	0.102	25	5.94	56	0.183	0.24	
22	*Vernonia noveboracensis*	3500	80	3	0.015	25000	1.2	0.168	0.168	25	13.00	42	0.400	0.52	
23	*Zizia aurea*	3500	80	6	0.03	11000	2.4	0.764	0.764	20	58.40	34	2.246	2.92	
24				85.63	0.42815										
25															
26															
27															
29	**Forbs- Wild Collections**														
30	*Achillea millefolium (added more than original list b/c 2020 seed)*	3500	80	9	0.045	178000	3.6	0.0708	0.0708	16	1.62	91	0.078	0.10	original amount request .03, but added more b/c old seed
31	*Asclepias syriaca (WC)*	3500	80	0.45	0.00225	4000	0.18	0.158	0.158	15	6.14	50	0.315	0.41	
32	*Chamaecrista nictitans (WC) (annual)*	3500	80	2.125	0.010625	12886	0.85	0.231	0.231	6	3.60	50	0.462	0.60	
33	*Cirsium discolor (just what we had) (WC) (biennial)*	3500	80	0.08	0.0004	5000	0.032	0.022	0.022	40	2.33	50	0.045	0.0582	
34	*Erigeron pulchellus*	3500	80	8.7	0.0435	315000	3.48	0.039	0.039	10	1.01	50	0.07733	0.10	this amount added b/c unclean
35	*Fragaria virginiana (greenbelt sending .1 oz)*	3500	80	2.2	0.011	83000	0.88	0.037	0.037	18	1.74	50	0.074	0.10	

36	*Lespedeza capitata (WC)*	3500	80	1.98	0.0099	9500	0.792	0.292	0.292	15	11.38	50	0.584	0.76	
37	*Solidago nemoralis*	3500	80	4	0.02	250,000	1.6	0.022	0.022	20	1.16	50	0.045	0.06	0.14 added b/c unclean
38	*Spiraea alba (WC)*	3500	80	8	0.04	300,000	3.2	0.037	0.037	50	4.85	50	0.075	0.10	
39				49.295	0.246475										
40															
41	**To order from other sources**														
42															
43	*Chamaecrista fasciculata (PA ecotype from Ernst via Greenbelt) (annual)*	3500	80	5	0.025	2700	2	2.5926	2.5926	6	22.5	90	2.881	3.74	
44	*Carex annectens (cool season) (prefers wetter conditions)*	3500	80	2	0.01	45000	0.8	0.0622	0.0622	20	3.24	50	0.124	0.16	
45	*Carex brevior (cool season) (Ernst not ecotype)*	3500	80	11.1	0.0555	29000	4.44	0.5359	0.5359	8	5.68	98.14	0.546	0.71	
46	*Desmodium canadense (Ernst PA ecotype)*	3500	80	7.76	0.0388	5500	3.104	1.975	1.975	8	20.80	98.77	2.000	2.600	
47	*Juncus tenuis (Greenbelt)(cool season)*	3500	80	0.55	0.00275	93750	0.22	0.008	0.008	4	0.09	50	0.016	0.021	
48				11.65	0.06825										
49															
50															
51	**Graminoids (of 126% graminoids total: ~86% warm, 20%cool)**														
52	**Total % of Mix: ~53 (58% if Andropogon virginicus is added later)**														
53	*Andropogon gerardii (we have but not enough but not the orig. 3.82 oz requested) (WC) (oz column I adjusted for 50% more seed)*	3500	80	2.02	0.0101	10000	0.808	0.283	0.424	10	11.03	50	0.848	1.10	
54	*Andropogon virginicus (oz column I adjusted for 50% more seed) (we could not locate this during the seeding, so the plan will be to add the 5% Andropogon in the spring for a total of 0.39oz)*	3500	80	5	0.025	70000	2	0.100	0.100	15	3.90	50	0.200	0.26	originally wanted 0.39 oz to be added for 50% increase for fall seeding
55	*Elymus canadensis (cool season) (we added more than original list (it was .35 oz) bc the seed was not clean)(oz column I adjusted for 50% more seed)*	3500	80	1.05	0.00525	5200	0.42	0.283	0.283	10	7.35	50	0.565	0.74	
56	*Elymus virginicus (cool season)*	3500	80	5.045	0.025225	3500	2.018	2.018	2.018	10	52.47	50	4.036	5.247	
57	*Eragrostis spectabilis) (oz column I adjusted for 50% more seed) (.25 oz not-cleaned added, then .1478 oz mostly cleaned added too for total of .3978)*	3500	80	20.4	0.102	280000	8.16	0.102	0.153	35	13.92	50	0.306	0.3978	not all clean so this is more than the original .2 oz or 10% we planned to add
58	*Panicum virgatum (adjusted for 50% more b/c it's warm season)*	3500	80	1.8	0.009	14000	0.72	0.180	0.270	10	7.02	50	0.540	0.70	
59	*Schyzachyrium scoparium from Ernst (albany pinebush) (due to a lack of Andropogon virginicus and little Andropogon gerardii, we upped the percentage of this Schizachyrium from 31.05% to 36% of the mix (oz column adjusted 50% up for fall broadcast)*	3500	80	36	0.18	15000	14.4	3.360	5.040	2	16.31	80.32	6.275	8.16	
60	*Schizachyrium scoparium (estimated weight)(WC)(oz column adjusted for 50% more seed)*	3500	80	3	0.015	15000	1.2	0.280	0.420	10	19.50	28	1.500	1.95	
61	*Sorghastrum nutans (grown seed) (oz column I adjusted for 50% more seed)*	3500	80	10.66	0.0533	11000	4.264	1.357	2.035	10	62.99	42	4.845	6.30	
62	*Tridens flavus (used what we had) (oz column I adjusted for 50% more seed)*	3500	80	13	0.065	26000	5.2	0.700	1.050	10	27.30	50	2.100	2.73	
63					0.489875										

64	**TOTALS**				**1.23275**					$Total estimated	**537.72**		OZ total	47.39	
65													POUNDS total	2.96	
66	nurse crop														
67	Lolium multiflorum (Prairie moon)	2625	seeded at 12 lbs/acre		11.5 oz								nurse crop	11.6 oz	

Bibliography

Books cited and consulted:

Camu, Basil. (2024) *From Wasteland to Wonder: Easy Ways We Can Help Heal Earth in the Sub/Urban Landscape.* Raleigh, NC: Leaf & Limb.

Diboll, Neil and Cox, Hillary. (2023) *The Gardener's Guide to Prairie Plantings.* Chicago, IL: The University of Chicago Press.

Packard, Stephen and Cornelia F. Mutel, editors. (2005/1997) *The Tallgrass Restoration Handbook for Prairies, Savannas, and Woodlands.* Washington, D.C: Island Press.

Vogt, Benjamin. (2023) *Prairie Up: An Introduction to Nature Garden Design*. Champaign, IL: University of Illinois Press.

Weaner, Larry and Christopher, Thomas. (2016) *Garden Revolution*. Portland, OR: Timber Press.

Articles, podcasts, and course material cited and/or consulted:

Bamert Seed. "The Role of Potassium & Phosphorous in Native Prairie Restoration." https://bamertseed.com/the-role-of-phosphorus-amp-potassium-in-native-prairie-restoration/

Bartow, Amy. "Establishment of pollinator mixes based on seeding rates and seeding dates." Corvallis, Oregon: 2021. https://www.nrcs.usda.gov/plantmaterials/orpmcsr13783.pdf

Christopher, Thomas. "Creating a Meadow the Ecological, Easy Way." *Growing Greener,* July 3, 2024: https://www.thomaschristophergardens.com/podcasts/creating-a-meadow-the-ecological-easy-way

Diboll, Neil. "Designing Natural Landscapes: Meadow Design with Native Prairie Seed Mixes." Prairie Nursery. https://www.prairienursery.com/media/pdf/designing-natural-landscapes-meadow-design-with-native-prairie-seed-mixes.pdf

Diboll, Neil. "Five Steps to Successful Prairie Meadow Establishment." Westfield, WI: Prairie Nursery. https://docs.lib.purdue.edu/cgi/viewcontent.cgi?article=1538&context=roadschool

Diboll, Neil. "Site Preparation and Prairie Seeding Methods." Prairie Nursery. https://www.prairienursery.com/media/pdf/site-preparation-and-prairie-seeding-methods.pdf

Hannan, Joe. "Interpreting Soil Reports." https://www.extension.iastate.edu/smallfarms/interpreting-soil-reports

Houck, Morris. “Plant Materials Technical Note No. 11: Understanding seeding rates, recommended planting rates, and pure live seed (PLS).” United States Department of Agriculture, Natural Resources Conservation Service, Alexandria, LA.

Jordan, Sarah Foltz, and Jess Kay Cruz, Kelly Gill, Jennifer Hopwood,etc. Xerces Society. “Organic Site Preparation for Wildflower Establishment.” Serial number 16-027 and Version No. 2. https://xerces.org/publications/guidelines/organic-site-preparation-for-wildflower-establishment

Kaspari, Michael. “Potassium as a Game Changer in Prairie Food Webs.” December 24, 2022: https://michaelkaspari.org/2022/12/24/potassium-as-a-game-changer-in-prairie-food-webs/

Kilde, Rebecca. “Going Native: A Prairie Restoration Handbook for Minnesota Landowners.” Minnesota Department of Natural Resources. https://files.dnr.state.mn.us/assistance/backyard/prairierestoration/goingnative.pdf

Kivit, Erik. “Are Herbicides Dangers?,” from *News from Hudsonia, Volume 37, no. 1, Summer 2023*, p. 2-5: https://static1.squarespace.com/static/631110deada85121498e9d85/t/64baa0a0fcf8f607cb509ec5/1689952419521/NFHsu23+37-1.pdf

Knab-Vispo, Claudia and Conrad Vispo, Natasha Djuric, and Megan Garfinkle. (Draft 2023): “Native Meadow Trial at the Hudson Valley Farm Hub
Botany Report for the First Six Seasons: 2017-2022.” Hawthorne Valley Farmscape Ecology Program, New York.

Little, Clif. “Fertility Management of Meadows.” Ohioline: Ohio State University Extension. June 14, 2016: https://ohioline.osu.edu/factsheet/anr-5

Meissen, Justin and Alec Glidden et al. “Seed Mix design and first year management influence multi-functionality and cost-effectiveness in prairie reconstruction.” The Journal for the Society of Ecological Restoration. July 22, 2019: https://onlinelibrary.wiley.com/doi/10.1111/rec.13013

Neal, Cathy. “Planting for Pollinators: Establishing a Wildflower Meadow from Seed.” University of New Hampshire Cooperative Extension. https://extension.unh.edu/resource/planting-pollinators-establishing-wildflower-meadow-seed-fact-sheet

Phillips-Mao, Laura. “Restoring your Crop field to Conservation Prairie.” The Nature Conservancy and Univ. of Minnesota: 2017. https://www.nature.org/content/dam/tnc/nature/en/documents/Restoration-Guide-Crop-to-Conservation-Prairie.pdf

Plantlife’s ‘Meadow Hub.’ “Managing Meadows of all Sizes with mowing.” https://meadows.plantlife.org.uk/3-maintaining-meadows/managing-meadows-of-all-sizes-with-mowing/. Accompanying Youtube video, “Preparing and sowing wildflowers on an existing lawn:”

https://www.youtube.com/watch?v=l_ITwIZ4EUQ

Roach, Margaret. “In the Garden” series: *Can You Get Rid of Your Front Lawn without Offending the Neighbors.* The New York Times, September 25, 2024: https://www.nytimes.com/2024/09/25/realestate/wildflower-meadow-yard-lawn.html

Seymour, Randy and John Seymour. “Six Basic Elements For a Successful Native Grass and Forbs Establishment.” Roundstone Native Seed LLC: 2012. https://roundstoneseed.com/pdf/SixBasicElements%20-%20including%20coastal%20plains.pdf

Sturm, Alice and Mahan Rykiel Associates, Stephanie Frischie. (2020) “Mid-Atlantic Native Meadows: Guidelines for Planning, Preparation, Design, Installation, and Maintenance.” The Xerces Society for Invertebrate Conservation: Portland, Oregon.

“Successfully Establishing Meadows from Seed in Delaware and the Mid-Atlantic.” University of Delaware Cooperative Extension. udel.edu: https://www.udel.edu/academics/colleges/canr/cooperative-extension/fact-sheets/establishing-meadows/

Wallace, Vickie, and Alyssa Siegel-Miles. “Preparing a site and planting a meadow.” UConn extension: https://wctrust.org/wp-content/uploads/2023/07/Meadow-Prep.pdf

Weaner, Larry. (October 5th, 2021). “Native Meadow Design: An Intensive One-Day Workshop Developed by Larry Weaner.” Glenside, PA: New Directions in the American Landscape.

Williams, Dave. “Prairie Restoration Series: Designing Seed Mixes.” Tallgrass Prairie Center: 2018. https://scholarworks.uni.edu/cgi/viewcontent.cgi?article=1038&context=tpc_facpub

Xerces Society. “Establishing Pollinator Meadow from Seed.” 2013: https://www.xerces.org/sites/default/files/2018-05/15-020_02_XercesSoc_Establishing-Pollinator-Meadows-from-Seed_web.pdf

Other sources of interest:

Understanding Pure Live Seed: https://www.ernstseed.com/resources/pure-live-seed/

Weed information: https://extension.umd.edu/resource/manage-weeds-without-chemicals-maryland/

Seeds of Success protocol from the Bureau of Land Management: https://www.blm.gov/sites/blm.gov/files/program_nativeplants_collection_quick%20links_Quick%20Guide%20to%20the%20SOS%20Protocol.pdf

Fertility Management of Meadows: https://ohioline.osu.edu/factsheet/anr-5 (for Potassium information)