FINAL STUDY REPORT (March/2026)
Norman A. Berg Plant Materials Center
Beltsville, Maryland

Tall Fescue and Orchardgrass Growth Curves in Beltsville, Maryland

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ABSTRACT

This three-year field study monitored the seasonal growth patterns of tall fescue (*Schedonorus arundinaceus* (Schreb.) Dumort., nom. cons. (synonym *Lolium arundinaceum* (Schreb.) S.J. Darbyshire) and orchardgrass (*Dactylis glomerata* L.) under typical pasture and hayland management conditions in Beltsville, MD from 2022-2024. The goal of the study was to develop species-specific growth curves to aid in sustainable forage management. To accomplish this, we harvested plots of each grass and measured the growth regularly during the growing season. We observed that 'Max Q' tall fescue produced less on average (6814 lb/A) but maintained steadier late-season productivity and 'Persist' orchardgrass produced more growth on average (7609 lb/A). Total productivity for both grasses was dependent on rainfall. The growth models developed from this data provide a predictive framework for optimizing harvest timing, balancing forage quality and yield, and reducing the risk of erosion associated with overgrazing. These findings support adaptive management strategies that enhance pasture health, improve livestock performance, and promote ecological resilience in forage systems of the mid-Atlantic Piedmont.

INTRODUCTION

About 12% of Maryland's farmland (over 180,000 acres) is growing pasture grasses and hay for animals to eat (NASS, 2022). Growth curves are diagrams that are commonly used to communicate estimates of how much grass will be in a field at any point in the season. Early in the spring, many grasses devote their energy to leaf production and stem elongation, so their biomass increases faster than it does later in the summer, when water is more limiting and when the plants are devoting more resources to reproduction (see a summary of plant growth phases in Appendix I.) This means that fields can be sustainably grazed for longer periods in the spring than they can in the summer and fall. The NRCS has used estimated growth curves, (for example Lacefield et al., 2003 and Roberts et al., 2009) to advise producers on how many animals per acre they should have on pastures for sustainable grazing management. It is important to verify these estimates for the commonly used cultivars in our region, so that producers can make informed decisions about the timing of livestock in paddocks.

This report provides growth curves for 'Max Q' tall fescue (*Schedonorus arundinaceus)* and 'Persist' orchardgrass (*Dactylis glomerata),* in Beltsville, MD, 2022-2024. Tall fescue and orchardgrass are widely used cool season grasses in Maryland (NRCS staff, personal communication, January 16, 2026). We initially chose 'Bronson' tall fescue for the study, however this endophyte-free variety was difficult to establish, so we selected another variety, 'Max Q' novel endophyte tall fescue. Orchardgrass is currently the preferred forage grass for hay in Maryland (NRCS staff, personal communication, January 16, 2026), and we chose 'Persist' orchardgrass because it is widely used in Maryland (NRCS staff, personal communication, June 27th, 2019), and because it is one of the orchardgrass varieties with good stand establishment and yield (Olson et al. 2021). The data we provide will increase the accuracy of models that predict erosion and grazing

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and hay production in various NRCS conservation planning tools including MD-Graz, Water Erosion Prediction Project (WEPP), Wind Erosion Prediction System (WEPS), and Revised Universal Soil Loss Equation 2 (RUSL 2).

Tall fescue and orchardgrass are widely used for pasture, hay, and silage (Casler et al., 2020) and seasonal harvest data has been collected in areas near Maryland (Johnson, 2024 and Jones & Tracy, 2018). However, these studies did not collect from harvests throughout the season, so our data will help producers understand detailed grass growth trends. Kiniry et al. (2018) collected data on tall fescue growth throughout the season but used different cultivars (Kentucky 31' and 'BarOptima'), in a different location (Missouri), in a different time frame (2011-2013). Our dataset complements theirs by providing information on tall-fescue growth with Maryland climatic factors.

Pasture Forage Nutrition

An important aspect of a pasture is the nutrients the grasses provide. The forage nutrient content is dependent on nutrient and water availability (in the soil or applied during the growing season), time of year, plant species, and plant growth stage (Buxton, 1996). We present the data in 6 metrics that are most relevant to forage nutrition. Crude protein (CP) is critical for growth and reproduction of animals. Total digestible nutrients (TDN) is a measurement that includes the digestible fiber, protein, lipid and carbohydrates, reflecting how much energy the animal can get from its food. Acid detergent fiber (ADF) reflects the least digestible parts of plants. Neutral detergent fiber (NDF) estimates the total fiber content of the grass; this is an important value because it affects how much cows will eat, how their food is digested, as well as the quality and quantity of milk they produce (Shi et al. 2023). Neutral detergent fiber digestibility 48 (NDFD-48) is an assay to determine how much energy and nutrients a grazer can digest over 48 hours. Lastly, relative forage quality (RFQ) is an index derived from the total nutrients and dry matter values that is often used to compare forages to help farmers determine what mix of forages to feed animals.

MATERIALS AND METHODS

We generated the growth curves by regularly clipping the grasses to the same height, weighing these samples, and calculating the change in biomass over time. 'Max Q' tall fescue and 'Persist' orchardgrass dry matter weights (cuttings) were collected every 7 – 50 days (weather dependent) during the growing season (April – December (tall fescue) and Apil – October (orchardgrass)) over a three-year period (2022-2024).

Site Information

The adjacent tall fescue (.43 Acre) and orchardgrass (.43 Acre) pastures are located at the Beltsville, MD Plant Materials Center. The tall fescue pasture soil (at coordinates 39.017853520971116, -76.85521118145513) is classified as a Russett-Christiana sandy loam soil, 2-5% slope, somewhat excessively drained (Soil Survey Staff, 2025). The orchardgrass pasture soil (at coordinates 39.0175450969141, -76.85437433230408) is classified as a Fallsington sandy loam with a high-water table (Soil Survey Staff, 2025). Initial soil testing analysis determined the soil organic matter to be 1.7% (tall fescue) and 2.2% (orchardgrass). The USDA Plant Hardiness zone for this site is 7b, (ARS, 2023), with average monthly temperatures for (2006-2020) ranging from 78°F in July to 34°F in January, and a total average annual precipitation of 44.55in. (NCEI, 2023). Details of the precipitation patterns during this study period compared with 30-year averages are provided in Appendix 2.

Pasture Establishment
Prior to seeding, we tested the soils and determined that fertilization was necessary. The tall fescue pasture required 50 lb/A nitrogen and 87 lb/A potash (K_2O). The orchardgrass pasture required 3 tons/A lime, and 50 lb/A nitrogen. Herbicide (glyphosate) applications were used to control existing vegetation. Light tillage and broadcast seeding occurred in 2020 (August) at the rate of 6 lb/A (tall fescue) and 12 lb/A (orchardgrass). Regular mowing, periodic irrigation and broadleaf weed herbicide applications (as necessary) aided seedling establishment. No treatments were implemented during the 2021 growing season to allow for full stand establishment.

Experimental Design and Analysis
Tall fescue and orchardgrass were established in adjacent fields in a randomized complete block design with five replications. Because we anticipate that fields would be mowed or grazed 3 times a year, we treated our fields the same way, Mowing them based on the schedule in table 1. Data interpretation was prepared in MS Excel and in R.


Figure 1: A RCI plot forage harvester is used to clip and weigh a plot of 'Max Q' tall fescue.

Harvests (clippings)
We used an RCI Engineering 36A Research Plot Harvester, adjusted to clip the grass to 4" high, to harvest the 3' area sample (Figure 1). Gross field plot weights and the grasses' phenological growth stage descriptions (Appendix 1) were recorded at each clipping. Clipping was initiated when the grasses began to grow in the spring and ceased when the grasses senesced in the fall. These dates are presented in Table 1. For the monthly percent data visualizations, we added an extra datapoint before the green up for each species to indicate the lack of growth before the data collection. Kallenbach et al (2015) suggest measuring pasture mass frequently enough to detect changes greater than 10%. Our sampling method met this suggestion most of the time except during the fastest growth in the spring.

Table 1: Dates of data collection for 'Max Q' tall fescue and 'Persist' orchardgrass in 2022-2024. The value in parentheses at the end of each time frame is the number of clippings in that season.

	2022			**2023**			**2024**		
'Max Q' tall fescue	Mar. 31–Dec. 8 (27)			Apr. 6–Nov 30 (19)			Apr. 9–Dec. 5 (17)		
Fescue hay cuts	Jun. 2	Jul. 26	Dec. 16	May 11	Aug. 3	Dec. 3	May 14	Jun. 1	Dec. 5
'Persist' orchardgrass	Apr. 7 – Sept. 2 (19)			Apr. 6–Oct. 24 (17)			Apr. 9–Oct. 24 (14)		
Orchardgrass hay cuts	Jun. 2	Jul. 22	Sep. 2	May 11	Aug. 3	Oct. 24	May 14	Jul. 1	Oct. 24

Drying Procedures
Field samples (between 600 – 1000 grams) were collected directly after harvest, labeled, placed into cloth bags, weighed (to .1 gram), and dried in a forced air-drying oven. Field samples were dried at between 131° - 140° F for 48 hours to determine dry matter (DM) percentages. We converted our plot dry matter measurements to values in lb/A to share the dataset on AgDataCommons.

Pasture Fertility/Amendments

After initial soil testing analysis, biennial testing revealed soil fertility and/or pH amendment needs. Maintenance broadcast fertilization applications were made with a yield goal of 5 tons/A. Table 2 shows the maintenance fertilization timing and rates. Actual fertilization timing and dates are provided in Appendix 3.

Table 2: Maintenance fertilization timing and rates.

Timing	**Nitrogen (lbs./A)**
Green Up (Apr.)	60 - 80
After 1st Harvest (May/June)	50 - 60
Late Summer (Aug.-Sept.)	50 - 60
Late Autumn (Oct.-Nov.)	40 - 50
Seasonal Total	*200 - 250*

Pasture Climatic Factors

Grass growth rates will vary greatly based on climactic factors (available water and temperature). 2022-2024 Beltsville, MD monthly growing season (April – December) rainfall amounts, monthly temperature averages and long term (30 year) averages for each year are provided in Appendix 2. The fields were not irrigated.

Pasture Forage Nutrition

We collected and dried one sample of grass for forage nutrition sampling for each of the 5 replicates at the conclusion of each phenological growth stage for both grasses in 2024 (9 April, 23 April, 14 May, and 26 August). We submitted these 40 dried samples for analysis by University of Georgia Ag & Environmental Services Labs (see results in Appendix 4).

RESULTS AND DISCUSSION

In Figures 2, 3, 4 and Table 3, we present the results from the three-year study. The most prominent seasonal trend was that the first harvest had the highest yield (Figures 2 and 3). These findings are consistent with results for tall fescue and orchardgrass productivity studies in other regions (Michigan (Wiering et al. 2021); Missouri (Kiniry et al. 2018), Tennessee (Johnson 2024), and Virginia (Jones & Tracy 2018).

In our study, tall fescue grew later into the fall but orchardgrass was overall slightly more productive (Table 3). We analyzed the data separately by year and found that in 2023 (at first hay cut (or boot)) orchardgrass was more productive than fescue. In 2023, May precipitation was lower (almost 3 inches less) than the long-term average (Appendix 2, Figure e). Most of the grass growth occurs (for both species) in May (Figures 2 and 3), but tall fescue's spring growth was much reduced in 2023 (see Figure 2b) compared to other years, while orchardgrass spring growth was not drastically reduced (Figure 3b). This may be due to the different soil types and orchardgrass pasture's high-water table (see site information section). All data are available on AgDataCommons (Belt and Howe, 2026).

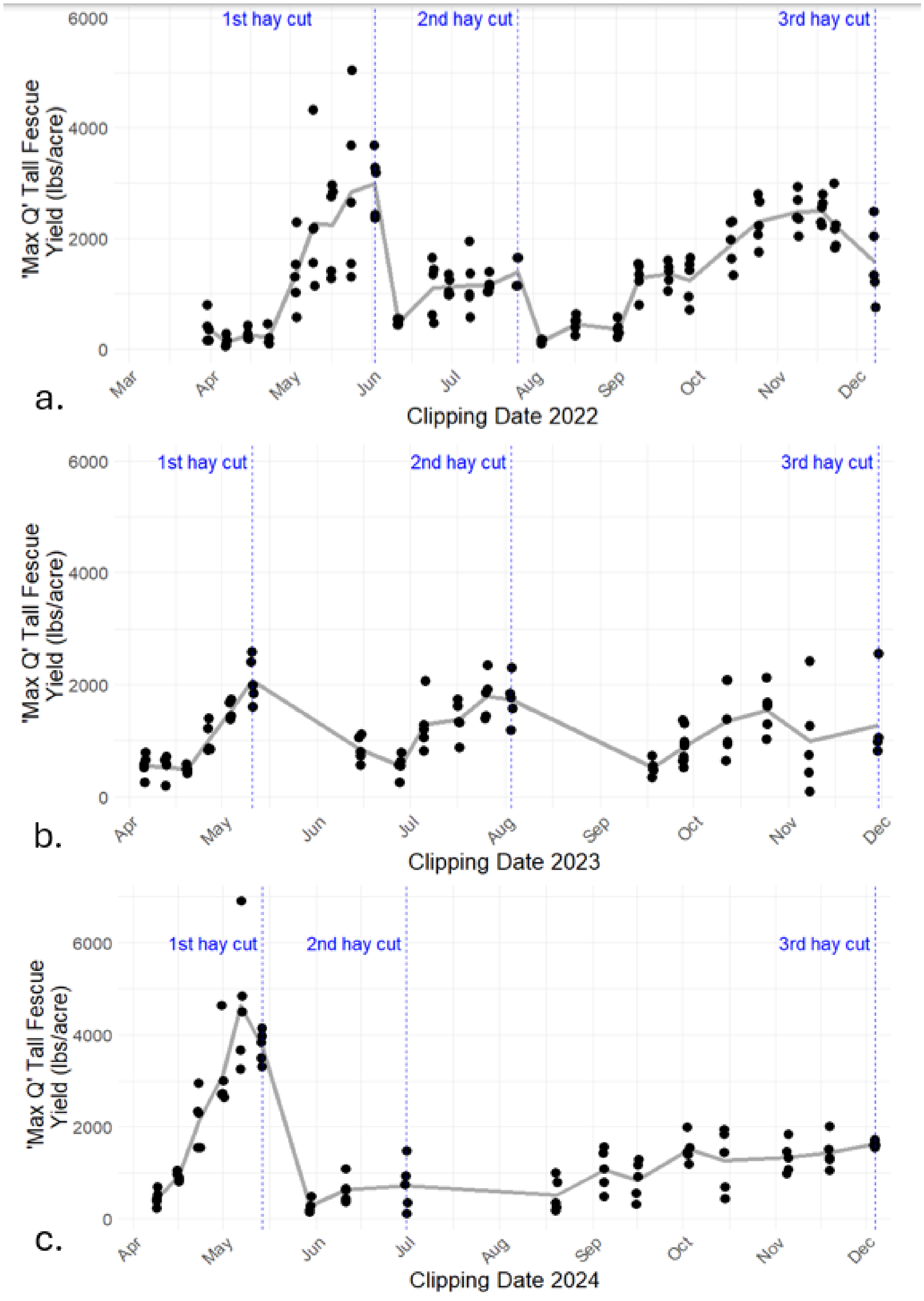

Figure 2: 'Max Q' Tall fescue harvest data for 2022-2024(a-c) Black spots represent the harvest from one plot, in lb/A. A grey line connects the average values for each harvest and blue dotted lines indicate the 3 hay cuts each season.

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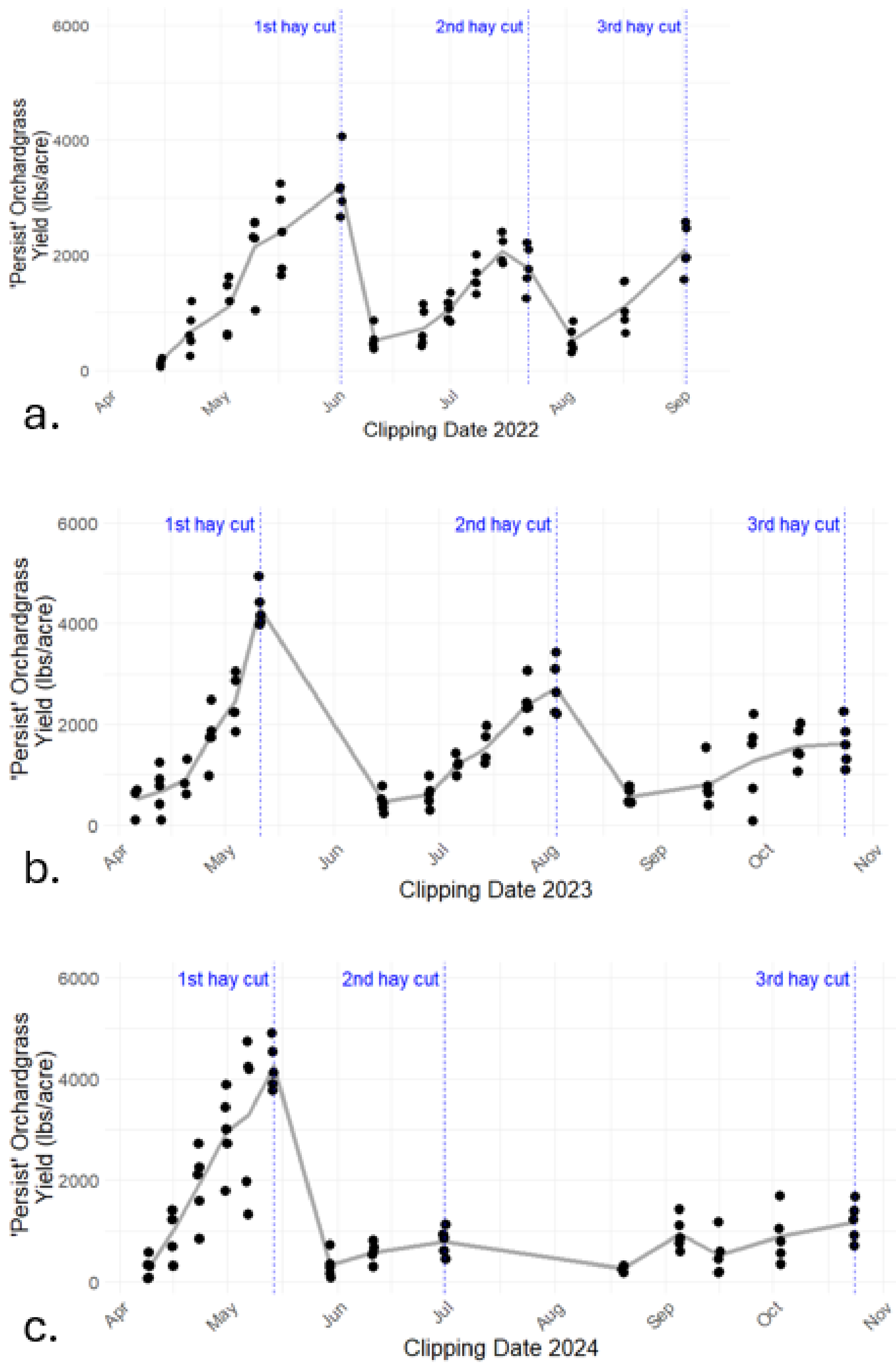

Figure 3: 'Persist' orchardgrass harvest data for 2022-2024(a-c) Black dots represent the harvest from one plot, in lb/A. A grey line connects the average values for each harvest and blue dotted lines indicate the 3 hay cuts each season.

We combined the data for each year to create a growth curve for each species (Figure 4), depicting the percentage of annual growth occurring in each month of the growing season.

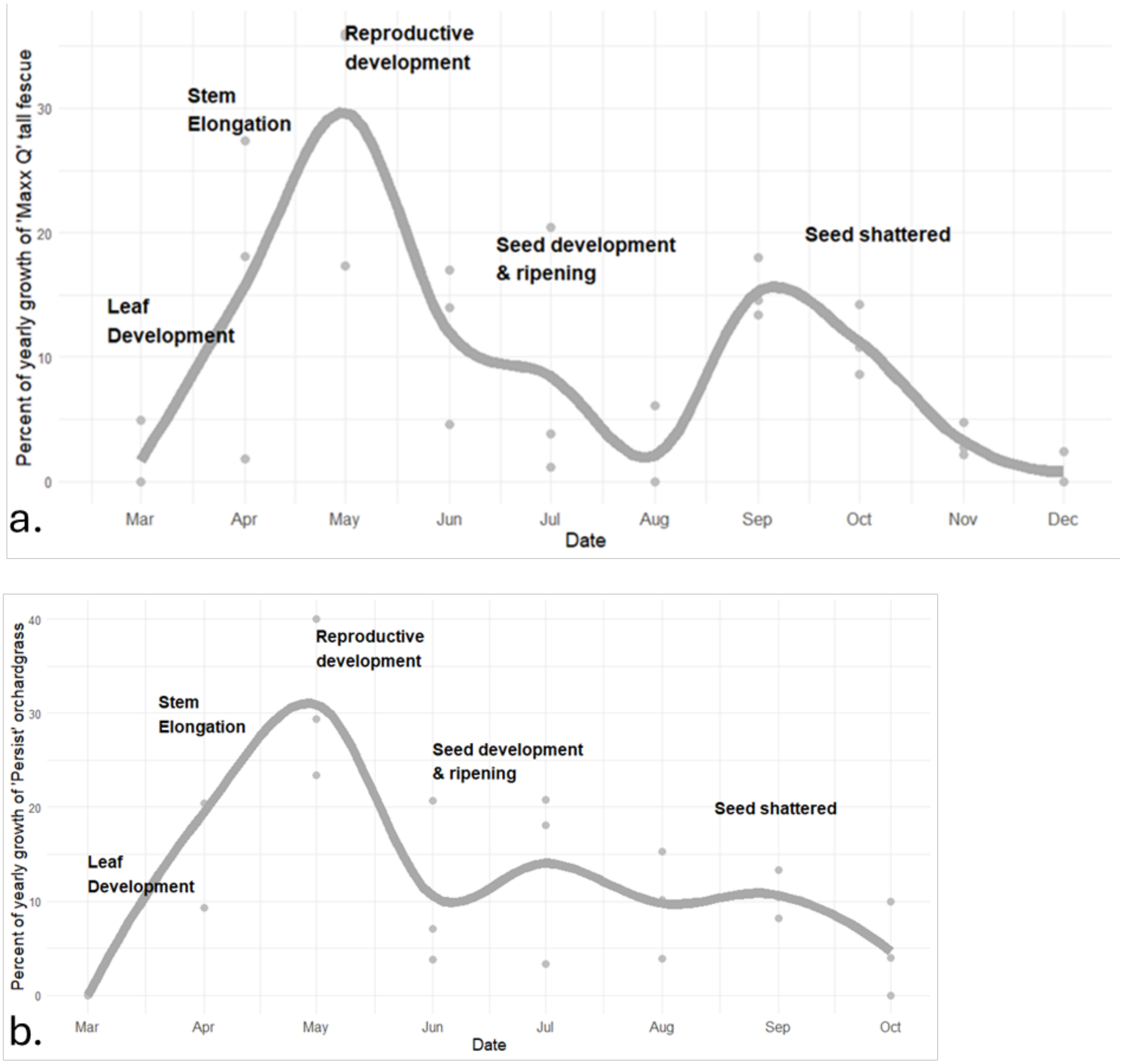

Figure 4: Monthly percentage of annual growth for (a) 'MaxQ' Tall Fescue and (b) 'Persist' Orchardgrass at Beltsville, MD. The grey line connects the average of the values for all 3 years (2022, 2023, and 2024) and is smoothed to create a curve.

One reason we collected this data was to inform a model (MD-Graz) that NRCS employees use to advise producers. This MS excel tool combines data on grass growth with animal needs to generate a Forage-Animal Balance Graph. This is a graph that compares pasture production (supply) to the livestock type and numbers (demand); if supply and demand are balanced, the grazing plan is likely to be sustainable. The forage growth estimates in the MD-Graz tool are from a similar physiographic province in Virgina, so it was important to us to compare our data to those values. MD-Graz values and our results are presented in Table 3 as a table providing the percentage of the annual grass growth occurring in each month. MD-Graz values are averaged over all cultivars for each species. We found that tall fescue growth mostly occurs in April, May, and June and orchardgrass growth occurs mostly in May and July, with significant production also in September.

Table 3: Production comparison of results from this study with regional estimates: Values presented indicate monthly percentage of total annual growth. The first and forth rows present data from this study, and the second and fifth rows indicate values previously used to estimate MD forage production. The third and sixth rows indicate the difference between the values from this study and the estimated values ND indicates that data was not collected while grass was not growing.

Grass	Production (lb/ac/yr.)	% of Annual Yield (DM) Produced Month											
		Jan	Feb	Mar	Apr	May	Jun	July	Aug	Sep	Oct	Nov	Dec
Tall Fescue 'Max Q'	6814	ND[2]	ND[2]	2	16	30	12	8	2	15	11	3	1
Tall Fescue (Endophyte Infected)	6350	1	3	10	24	21	9	4	5	7	9	5	2
Difference 'Max Q' - MD Graz	464			**-8**	**-8**	**9**	**3**	**4**	**-3**	**-8**	**-2**	**-2**	**-1**
Orchardgrass 'Persist'	7609	ND[2]	ND[2]	0	19	31	10	14	10	11	5	0	0
Orchardgrass	7800	1	4	14	20	22	9	4	6	6	9	4	1
Difference 'Persist' - MD Graz	-191			**-14**	**-1**	**9**	**1**	**10**	**4**	**5**	**-4**	**-4**	**-1**
Tall Fescue 'Bar Optima'[1]	5985	ND[2]	ND[2]	0	25	22	26	4	7	1	13	2	0

[1]Kimiry et al. (2018) (MO) [2]No Data

Plant Nutrition Analysis

The seasonal changes in forage quality through some of the 2024 growing season is presented in Figure 5. Typically, forage quality decreases with maturity (Hoffman et.al., 2003). In our dataset, some metrics of forage quality slightly increased late season (Aug 26) both tall fescue and orchardgrass (lower values for ADF, NDF, and higher values for CP in Figure 5). This may be because of grass regrowth resulting from above average August rainfall (see 2024 rainfall in Appendix 2). However, the RFQ value did not increase in August because the grass was at a senescent life stage.

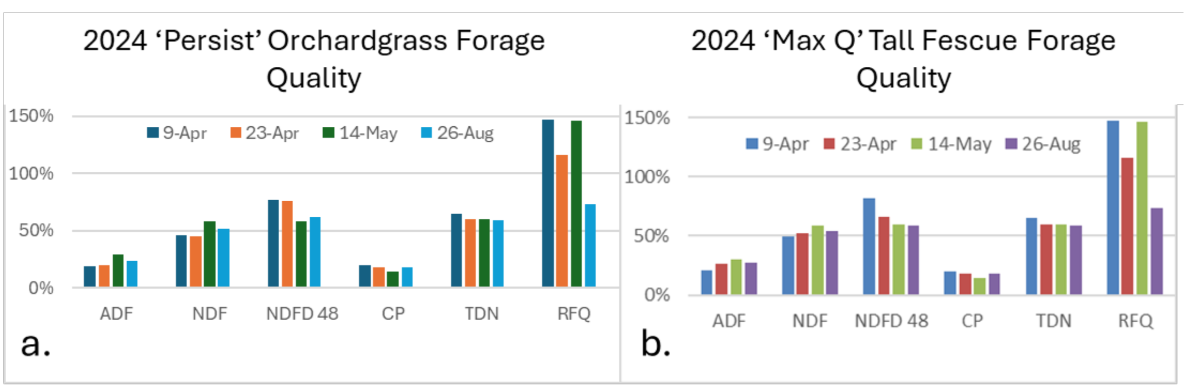

Figure 5: : 2024 Seasonal forage quality for orchardgrass (a) and tall fescue (b), measured 4/9/24, 4/23/24, 5/14/24, and 8/26/24. Data is presented as a percentage of dry matter, except for RFQ (relative food quality), which is presented as a value: RFQ=TDN x DDMI /1.23. Other forage quality values are are ADF (Acid Detergent Fiber), NDF (Neutral Detergent Fiber), NDFD 48 (Neutral Detergent Fiber Digestibility (48 hours)), CP (Crude Protein), TDN (Total Digestible

Nutrients).

For both grasses, we found (Figure 5) that crude protein is highest in April, and declines throughout the summer, with a slight increase in August. In Casler et al.'s (2020) research, they found that orchardgrass has lower CP and energy content than tall fescue, since it reaches anthesis earlier; but in our data, the timing of reproductive development (boot stage) generally occurred in May for both grasses. In a study that involved assessing nutritive values for tall fescue from the Mediterranean (Turkey), Akdeniz et al. (2019) found tall fescue producing higher fiber and less protein than we did, leading to a lower relative food value. However, they still recommend planting it for forage and pasture (as we do) because of its relatively high dry matter yield.

Our finding that the NDF of tall fescue and orchardgrass stayed at about 50% (Figure 5) indicates that mixing these grasses with other feed components could lead to optimal milk production in dairy cattle, since Shi et al. (2023) found that a diet with about 28% NDF total was best for milk production. Our NDF, and NDFD-48 values were slightly lower than the results from Wiering et al. (2021), who studied 'Intensive' orchardgrass and STF-43' tall fescue growth in Michigan.

Jensen et al. (2003) found that for orchardgrass, maturity of the grass had little effect on forage nutritional status, but water availability had an important impact: as water stress increased, forage nutritional value increased. This may explain the increase in relative food quality we observed in both grasses in May (Figure 5). In Jensen et al's (2003) work, they also found that cultivar also had a significant impact on nutritional status. The values they found for a variety of orchardgrass cultivars was in the range of values we found with 'Persist' orchardgrass (CP 19.5%; NDFD 73%; NDF 46%). Similarly, Küsters et al. (2021), who also studied orchardgrass response to moisture, found that drought stress led to decreases in NDF and ADF, but that adding moisture increased the values.

The RFQ values for our samples ranged from 75 to 150 (Figure 5); these values are in the range for fescue and orchardgrass reported by Hancock (2011).

CONCLUSIONS

Tall fescue and orchardgrass growth estimates in MD-Graz might be revised to the values that represent our results shown in Table 4 for the Piedmont physiographic region:

Table 4: Summary results from this study. The average total growth across all 3 years is provided for each grass in lb/A/yr. The monthly percentage of total annual growth, averaged across all 3 years is also provided for each grass.

Grass	Production (lb/ac/yr.)	% of Annual Yield (DM) Produced Month											
		Jan	Feb	Mar	Apr	May	Jun	July	Aug	Sep	Oct	Nov	Dec
Tall Fescue (Piedmont)	6814			2	16	30	12	8	2	15	11	3	1
Orchardgrass (Piedmont)	7609			19	31	10	14	10	11	5			

PA-Graz as well as VA-Graz Piedmont monthly production values may also need revision.

'Persist' orchardgrass was selected in part for this later season productivity (Conger 2003) so it might not represent usual values for other orchardgrass cultivars. Lastly, it might be better to not include growth estimates for January and February in MD-Graz, since no growth is documented for either grass in our study or in others (Kiniry et al. 2018)

Our overall yield estimates seem congruent with findings from other studies. Jones and Tracey (2018) also collected data on orchardgrass growth from a field cut three times (May, July, and October) in Orange, VA. Their average yield from 2014-2016 was similar to ours. They also observed relatively high biomass production before their mid-July harvests, as we did, though after mid-summer their harvest biomass generally decreased throughout the season, as it did in our study. Similarly Kiniry et al. (2018), whose Missouri study focused on different varieties of fescue (‘BarOptima’ and ‘Kentucky 31’) found, as we did, that about half of the forage mass was produced in the spring (April-June), with low production in the summer, and another quarter more produced in the fall (September-November; Figure 3 & Figure 4).

As the goal of this project was to provide information to producers on best management practices for grazing or haying while maintaining the health of pastures and hayfields, one limitation of the study is that it does not reflect the soil conditions of many of the farmlands in the region. We hope that with the information provided here, others can repeat similar projects in other regions to provide a fuller picture of how tall fescue and orchardgrass grow across the mid-Atlantic.

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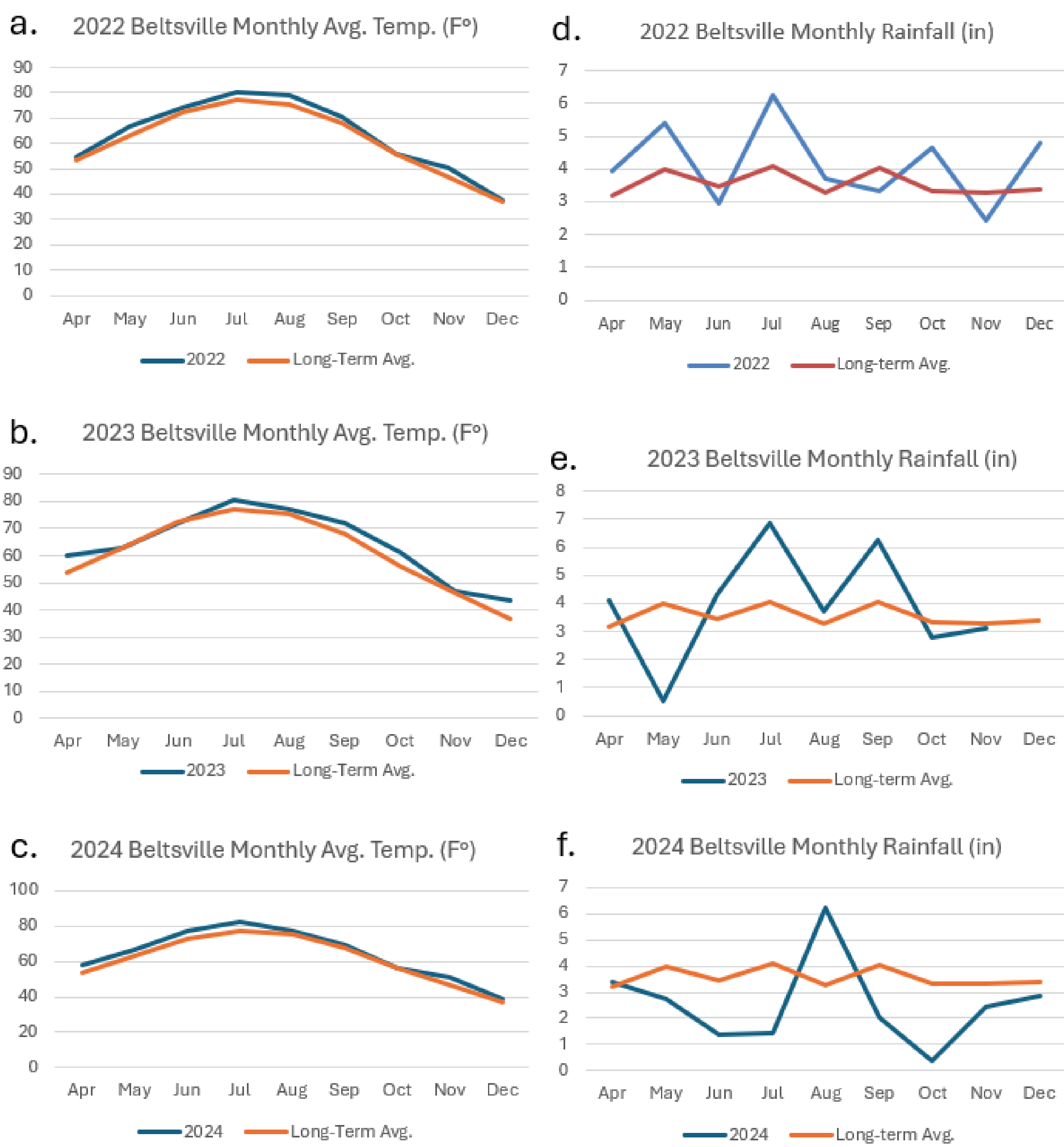
Appendix 1

Phenological Growth Stage Descriptions (Adapted from Moore et al. 1991)

Growth Stage	**Description**
Vegetative/leaf development	1. emergence of first leaf 2. first and second leaf collar 3. 1 to 4 leaves
Stem elongation	1. beginning of stem elongation 2. stem elongation and first node visible 3. second node visible
Reproductive development	1. boot stage (70% of plants) 2. inflorescence emerging – 1st spikelet visible 3. spikelets fully emerged 4. inflorescence emerged 5. anthers emerged/anthesis 6. post anthesis
Seed development and ripening	1. seed visible 2. milk stage 3. soft dough 4. hard dough 5. seed hard – physiological maturity 6. seed dry - ripe
Seed shattering	1. mature seed begins separating from the inflorescence 2. seed visible on the ground

Appendix 2

2022 – 2024 Growing Season Weather. a – c, average monthly temperatures (°F) for 2022-2024 compared with 30-year average (1991-2020). d - f, average monthly rainfall (inches) for 2022-2024 compared with 30-year average. (NCEI, 2023).



Appendix 3

2022 – 2024 Fertilization. Nitrogen and Potassium Application Dates and Rates:

	Date	Rate (lbs./A.)	Fertilizer	Formulation
	3/21/2022	60	Urea	46-0-0
	3/21/2022	30	Potash	0-0-60
	6/1/2022	60	Urea	46-0-0
	6/1/2022	30	Potash	0-0-60
	9/14/2022	60	Urea	46-0-0
	9/14/2022	30	Potash	0-0-60
	10/31/2022	50	Urea	46-0-0
	10/28/2022	25	Potash	0-0-60
Total Nitrogen		**230**		
Total Potassium		**85**		
	3/10/2023	60	Urea	46-0-0
	3/10/2023	30	Potash	0-0-60
	5/12/2023	60	Urea	46-0-0
	5/12/2023	30	Potash	0-0-60
	Late summer*	0		
	Late fall*	0		
Total Nitrogen		**120**		
Total Potassium		**60**		
	3/22/2024**	110	Urea	46-0-0
	3/22/2024**	55	Potash	0-0-60
	5/23/2024	60	Urea	46-0-0
	5/23/2024	30	Potash	0-0-60
	Late summer*	0		
	Late fall*	0		
Total Nitrogen		**170**		
Total Potassium		**85**		

* No application due to low precipitation (see weather appendix 2)

** higher application rate since prior 2023 late fall applications were missed

Appendix 4

2024 Forage Nutrition Quality Testing Results. Forage nutrition quality testing results from the Univ. of Georgia Ag. & Environmental Laboratory. Sampling took place for each of the 5 replicates at the conclusion of each phenological growth stage for both grasses. See Introduction (Pasture Forage Nutrition) for testing category descriptions.

Sample	Moisture	DM	ADF	ASH	LIGNIN	NDF	NDFCP	NDFD48	NFC
4/9/24 Fescue 1	4.46	95.54	20.96	6.76	2.62	48.66	4.59	81.33	19.45
4/9/24 Fescue 2	4.63	95.37	19.34	6.32	2.38	45.84	4.97	86.05	19.44
4/9/24 Fescue 3	4.70	95.30	21.00	6.72	2.57	48.51	5.01	81.72	16.70
4/9/24 Fescue 4	4.57	95.43	22.30	6.16	2.66	51.01	4.55	79.14	17.95
4/9/24 Fescue 5	4.49	95.51	20.22	5.36	2.73	49.23	4.89	82.25	18.02
4/23/24 Fescue 1	8.14	91.86	26.90	8.23	3.38	52.94	4.35	62.82	11.66
4/23/24 Fescue 2	8.17	91.83	25.33	6.45	3.02	51.23	4.20	67.47	15.45
4/23/24 Fescue 3	8.57	91.43	27.33	7.28	3.29	53.74	4.22	62.31	11.43
4/23/24 Fescue 4	7.16	92.84	28.21	8.60	3.75	53.96	4.50	63.94	10.56
4/23/24 Fescue 5	7.72	92.28	21.96	7.48	2.58	46.66	4.59	72.81	14.73
5/14/24 Fescue 1	8.05	91.95	33.02	7.44	4.88	61.34	4.16	55.07	8.40
5/14/24 Fescue 2	7.14	92.86	28.62	6.32	4.10	57.52	3.78	63.81	13.09
5/14/24 Fescue 3	7.01	92.99	29.34	6.44	4.34	57.94	3.66	62.38	14.26
5/14/24 Fescue 4	7.87	92.13	29.97	6.52	4.36	59.03	3.61	58.25	12.79
5/14/24 Fescue 5	8.20	91.80	30.31	8.09	4.75	57.17	4.21	58.80	8.76
8/26/24 Fescue 1	8.04	91.96	24.76	6.25	5.05	51.61	5.14	61.01	10.89
8/26/24 Fescue 2	8.34	91.66	25.73	7.56	5.24	52.39	5.71	60.64	9.26
8/26/24 Fescue 3	8.09	91.91	27.80	7.54	5.50	54.15	5.49	57.75	8.97
8/26/24 Fescue 4	8.35	91.65	28.22	8.39	5.45	52.29	5.77	59.40	8.89

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