agronomy

Article

Blooming and Forage Characteristics of Twelve Native Forbs Subjected to Repeated Defoliation

Jessica L. Prigge [1,*], Eric Bisangwa [1], Jonathan D. Richwine [2], Keagan J. Swilling [1] and Patrick D. Keyser [1]

[1] School of Natural Resources, University of Tennessee, Knoxville, TN 37996, USA; kswillin@vols.utk.edu (K.J.S.); pkeyser@utk.edu (P.D.K.)
[2] College of Agriculture, Arkansas State University, State University, AR 72467, USA
* Correspondence: jprigge@vols.utk.edu

Abstract: Insect pollinators are in population decline due to environmental and chemical stressors. Including native forbs in pastures could benefit grazers and pollinators; however, their forage and flowering characteristics are not fully documented. The objectives of our research were to evaluate 12 native forbs for persistence, forage mass, nutrient composition, and flowering patterns under repeated defoliation. Twelve species were planted in a small-plot experiment in 2018. Response variables were measured from 2020 to 2022. Annual (partridge pea, PPEA, *Chamaecrista fasciculata*) and biennial (black-eyed Susan, BESU, *Rudbeckia hirta*) species established high ($p < 0.05$) plant populations during the first season; however, the PPEA declined ($p < 0.05$) in forage mass during 2021. Tall species (Maximilian sunflower, MSUN, *Helianthus maximiliani*; cup plant, CUPP, *Silphium perfoliatum*) increased in forage mass, produced high-quality forage, and flowered during early fall. Lanceleaf coreopsis (LCOR, *Coreopsis lanceolata*) produced consistent ($p > 0.05$) forage mass and flowered in spring. The purple coneflower (PURC, *Echinacea purpurea*), Illinois bundleflower (ILBF, *Desmanthus illinoensis*), and oxeye sunflower (OSUN, *Helopsis helianthoides*) produced high-quality, consistent ($p > 0.05$) forage mass and flowered mid-season. Interseeding the BESU, ILBF, PPEA, LCOR, PURC, OSUN, and MSUN or CUPP would produce high-quality forage and floral resources throughout summer.

Keywords: forb; pollinators; defoliation; flowering; diversity; native; legumes; pastures

check for updates

Citation: Prigge, J.L.; Bisangwa, E.; Richwine, J.D.; Swilling, K.J.; Keyser, P.D. Blooming and Forage Characteristics of Twelve Native Forbs Subjected to Repeated Defoliation. *Agronomy* **2024**, *14*, 28. https://doi.org/10.3390/agronomy14010028

Academic Editor: Steven R. Larson

Received: 30 November 2023
Revised: 19 December 2023
Accepted: 20 December 2023
Published: 21 December 2023

1. Introduction

There are a wide variety of native forbs indigenous to the United States (U.S.), many of which are present across the Great Plains and throughout most latitudes spanning the country [1]. Many native forbs are present within early successional communities and prairies, and provide wildlife with cover, nesting sites, and nutritional resources [2]. Most nonwoody, native plants thrive in open spaces and provide suitable habitat resources for a variety of deer species [3,4], northern bobwhite quails (*Colinus virginianus* [3,5,6]), and wild turkeys (*Meleagris gallopavo* [7]). Compared to deciduous shrubs and trees, and some grass species, forbs can provide higher concentrations of energy and crude protein (CP) [4], which makes them potential valuable forages for livestock. In addition to mammals and birds, native forbs provide floral resources for critical insect pollinators, many of which are experiencing steep population declines across the U.S. due to factors like insecticide and herbicide use, disease, and habitat loss [8–12].

The eastern U.S. contains >20 million ha of grasslands, primarily as pastures, which support >40% of all U.S. cow–calf operations, along with a variety of other grazing animals [13]. These pastures present an opportunity to support both vital pollinators and growing livestock in a dual-purpose system. Through the incorporation of native forbs in a working land framework, a diversity of benefits can be achieved for both grazers and pollinators [13,14]. The existing literature has documented transplanted seedling persistence [15], forb response to annual and repeated defoliation [16,17], and the economic viability of incorporating native forbs [18]. However, persistence to repeated defoliation, as would occur with grazing, as well as their contribution to forage biomass, nutritive composition, and flowering patterns are largely undocumented for native forbs. Additionally, prior to the acceptance of new forage species into diversified pastures, it is important to document forage characteristics in a controlled environment. Therefore, the objectives of our research were to evaluate 12 native forbs for persistence, forage mass, forage nutrient composition, and flowering patterns in a small plot experiment subjected to repeated defoliation.

2. Materials and Methods

2.1. Plot Establishment

Research was conducted at the East Tennessee AgResearch and Education Center, Plant Science Unit in Knoxville, TN (35.90136°, −83.95602°). The experiment was established on 16 July 2018 in a 0.09 ha field. Treatments were arranged in a randomized complete block design, with 12 native forb treatments planted as monocultures with four replicates (Table 1; $n = 48$). Species were selected based on adaptation to the eastern U.S., plant physiology (i.e., forb or legume), life history (i.e., annual, biennial, perennial), seed cost and availability, and existing recommendations from various government agencies. Native forbs were planted in a prepared seedbed at a depth of 1 cm with a Hege1000 plot drill (Hege Equipment Inc., Colwich, KS, USA) within 1.5 by 7.6 m plots. Unplanted alleys (0.3 m) were included for plot access and management.

Table 1. Seeding rates (PLS † kg ha^{-1}) of 12 native forb species seeded on 16 July 2018 at the East Tennessee AgResearch and Education Center, Plant Science Unit, Knoxville, TN, USA.

Common Name	Scientific Name	Abbreviation	Seeding Rate PLS kg ha^{-1}	100,000 SEEDS ha^{-1} *
Canada goldenrod	*Solidago canadensis* L.	CAGO	0.5	50.6
Cup plant	*Silphium perfoliatum* L.	CUPP	8.9	19.6
Maximilian sunflower	*Helianthus maximiliani* Schrad.	MSUN	4.1	17.6
Oxeye sunflower	*Helopsis helianthoides* (L.) Sweet	OSUN	8.9	19.6
Eastern purple coneflower	*Echinacea purpurea* (L.) Moench	PURC	7.7	19.3
Lanceleaf coreopsis	*Coreopsis lanceolata* L.	LCOR	4.0	19.6
Upright prairie coneflower	*Ratibida columnifera* (Nutt.) Woot. & Standl.	UPPC	1.8	29.2
Black-eyed Susan	*Rudbeckia hirta* L.	BESU	1.8	62.5
Illinois bundleflower §	*Desmanthus illinoensis* (Michx.) MacMill.	ILBF	7.4	14.1
Partridge pea §	*Chamaecrista fasciculata* (Michx.) Greene	PPEA	10.7	15.0
Purple prairie clover §	*Dalea purpurea* (Vent.) Rydb.	PUPC	2.9	19.1
Showy tick-trefoil §	*Desmodium canadensis* (L.) DC.	STTF	5.3	8.5

† Pure live seed, PLS. * Approximate number of seeds planted ha^{-1} × 100,000. § Signifies legume species.

The soil was an Etowah silt loam (fine-loamy, siliceous, semiactive, thermic Typic Paleudult) and had a pH, phosphorus, and potassium content of 6.0, 6.8 kg ha^{-1}, and 103.4 kg ha^{-1}, respectively. Soil samples were collected annually in each replicate to a 15-cm depth to determine annual soil amendment requirements. Plots were to receive a lime application if the pH fell below 5.5. Phosphorus (P) or potassium (K) levels were to be amended if either fell below medium (<19.3 and 102.3 kg ha^{-1}, respectively); however, plots did not require amendments (lime, P, or K) during the study. Plots received an annual application of 67 kg ha^{-1} nitrogen (N) in the form of urea (CH_4N_2O) each April, 2019–2021. Plots were not irrigated.

To ensure yields were composed of our target species only, we made several attempts to control weed competition. However, due to forb rosette persistence through the winter and early spring, non-selective herbicides (e.g., glyphosate [N-{phosphonomethyl}glycine]), semi-selective herbicides (e.g., imazapic [(±)-2-[4,5-dihydro-4-methyl-4-(1-methylethyl)-5-

oxo-1*H*-imidazol-2-yl]-5-methyl-3-pyridinecarboxylic acid]), and broadleaf-selective herbicides (e.g., 2,4-D [2,4-dichlorophenoxyacetic acid]) were not used during the study. Manual removal of broadleaf weeds from the plots was conducted throughout each growing season to control perennial weeds and in the early spring to control cool-season annual weeds. Grasses were controlled using a grass-selective herbicide (Clethodium 2E [2-[(*E*)-*N*-[(*E*)-3-chloroprop-2-enoxy]-*C*-ethylcarbonimidoyl]-5-(2-ethylsulfanylpropyl)-3-hydroxycyclohex-2-en-1-one]) annually as needed at a rate of 1.2 L product ha^{-1} through broadcast spraying. This application rate was selected to control the most common grass weed species in the experimental plots.

Defoliation was applied at each harvest event and at the end of the growing season, using a rotary mower to mow the entire plot to a 20 cm stubble height and allowing the remaining forage to regrow.

2.2. Plant Heights and Plant Densities

Plant heights and plant densities were collected as measures of plant persistence after establishment. Plant heights were recorded weekly (Table 2) throughout the growing season except for the three-week period following each harvest. Plant heights were based on actively growing material and not senescent material remaining after previous harvests. Each plot was randomly sampled in five locations using a meter stick. Purple prairie clover (PUPC) was not measured due to poor establishment.

Table 2. Data collection schedule for response variables.

Response Variable	Collection Schedule		
	2020	**2021**	**2022**
Plant heights	Weekly	Weekly	Weekly
Plant densities	June July September	June September	June September
Forage mass and forage nutrient composition	June July September	June September	September
Flowering characteristics	Weekly	Weekly	Weekly

Plant densities were measured before every defoliation during the growing season (May–September) by sampling three, randomly located 0.25 m^2 quadrats per plot. For plots with minimal forb growth (i.e., <10% cover), all plants within the plot were counted.

2.3. Forage Mass

Forage was harvested when the majority of the plants were above 20 cm, the recommended harvest height for native grass hay [19], or approximately every 6 to 8 weeks. Droughts in 2021 and 2022 decreased the number of harvests compared to 2020 [20]. Forage mass was not evaluated in 2022 due to an abundance of senescent material for most of the species at the time of harvest. To determine forage mass, four 0.25 m^2 quadrats were sampled in conjunction with plant density by harvesting the forbs within the quadrat to a 20 cm stubble height. Samples were combined by plot and sampling date and then dried in forced-air ovens (Wisconsin Oven Corporation, East Troy, WI, USA) at 55 °C until they maintained a constant mass (approximately 72 h) to determine dry matter content. All remaining vegetation within plots was mowed to a 20 cm stubble height immediately after sampling. Canada goldenrod (CAGO) did not establish until late 2022 and, therefore, was not evaluated for forage mass.

2.4. Forage Nutrient Composition

Dried samples were ground using a Wiley Mill (Thomas-Wiley Laboratory Mill Model 4, Arthur H. Thomas Co., Philadelphia, PA, USA) to pass through a 2 mm screen, followed by a cyclone sample mill (UDY Corporation, Fort Collins, CO, USA), where they were ground to pass through a 1 mm screen [21].

Samples were sent to a commercial forage laboratory (Dairyland Laboratories, Inc., Arcadia, WI, USA) to be analyzed for forage nutrient composition using wet chemistry. Specifically, forbs were analyzed for CP, neutral detergent fiber (NDF), and acid detergent fiber (ADF). The wet chemistry analysis procedures and calculations are as follows: CP (N $\times$ 6.25; AOAC Official Method 990.03 [22]), NDF [23,24], and ADF (AOAC Official Method 973.18 [25]). All nutrients were evaluated on a dry matter (DM) basis, and results are presented in g kg^{-1} DM.

Canada goldenrod and PUPC lacked sufficient forage mass for analysis. In September 2022, forage nutritive composition was not evaluated for the black-eyed Susan (BESU), Illinois bundleflower (ILBF), partridge pea (PPEA), purple coneflower (PURC), showy tick trefoil (STTF), or upright prairie coneflower (UPPC) due to their senescent state at harvest.

2.5. Flowering Characteristics

Maturity stage was recorded weekly in conjunction with plant height measurements. Maturity stage categories were vegetative, flowering, mature, and senescent. Each stage was scored on a scale from 0 (none of the plants within the plot exhibited the maturity stage) to 100% (all of the plants within the plot exhibited the maturity stage). Canada goldenrod and PUPC did not exhibit flowers during the study and were not evaluated for flowering duration.

2.6. Statistical Analysis

Analysis was conducted using R software (version 4.3.1, R Foundation for Statistical Computing, Vienna, Austria) running RStudio (version 2023.6.2.561, Posit Software, Boston, MA, USA), and statistical significance was set at $p \leq 0.05$. Treatment differences were compared for each response variable using mixed-effects ANOVA running a Type III Wald F test with Kenward–Roger df. Mean separations were compared using Tukey's honest significant difference test. Transformations were applied to plant height (square-root), plant density (sixth root), forage mass (fourth root), forage nutritive composition (CP, NDF, ADF to the square, fourth, and fourth root, respectively), and flowering season length (second power). Response variables transformed for model analysis requiring normally distributed data were back-transformed for result presentation. Plant heights were analyzed; the species and annual Julian date and year were fixed effects, while the replicate was a random effect. The annual Julian date was treated as a repeated measure. Plant densities were analyzed; the species and the number of preceding harvests were fixed effects, while the replicate was a random effect. Forage mass was summed for each year and analyzed by species, with the year as a fixed effect while the replicate was a random effect. Species were not directly compared because the objective was to evaluate individual species' persistence in response to repeated defoliation. Forage nutrient parameters and flowering period were each averaged by species and analyzed; the species was a fixed effect, and the year and replicate were random effects. The year was included as a random effect to model the mean expected nutrient composition and flowering periods. The median flowering date was analyzed using a fixed-effects model in which the species and flowering period length were fixed effects. Trend slope, intercept, and R-squared values were derived from the linear regression model. All two- and three-way interactions of main effects were included in models as fixed effects.

3. Results

3.1. Temperature and Precipitation

The temperature from 2020 to 2022 was generally similar to the 30-year means (Figure 1), while the precipitation was inconsistent compared to the 30-year means. However, the temperature in 2022 remained above the 30-year mean, as it did in August 2021. The precipitation in July 2022 and August 2020 and 2021 all exceeded the 30-year mean. The precipitation was lower in June 2020 and 2022, as well as in July 2020 and 2021, and was relatively inconsistent throughout the years in July and August.

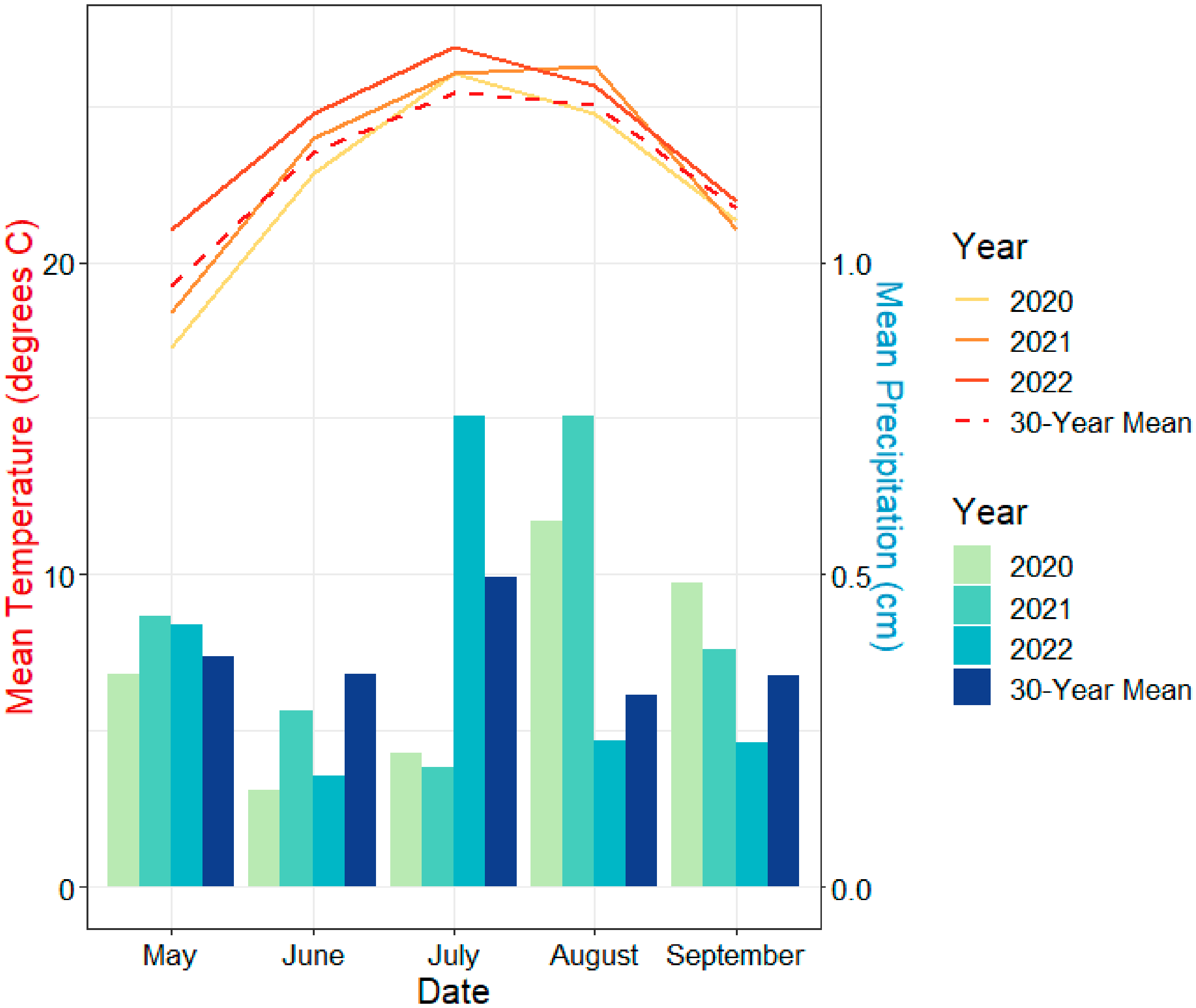

Figure 1. Monthly air temperature (°C) and precipitation (cm) for Knoxville, TN, USA, May–September 2020–2022. Weather data obtained from https://www.weather.gov/wrh/Climate?wfo=mrx (accessed on 18 November 2023).

3.2. Plant Heights and Plant Densities

Plant heights had a three-way interaction with species, Julian date, and year (Table 3; Figure 2; $p < 0.01$). We did not analyze PUPC due to poor initial establishment. The cup plant (CUPP), Maximilian sunflower (MSUN), and oxeye sunflower (OSUN) were the tallest species averaging >40 cm, while the PPEA, STTF, and UPPC were the shortest species averaging <30 cm ($p < 0.01$). The black-eyed Susan, CUPP, lanceleaf coreopsis (LCOR), OSUN, PURC, STTF, and OSUN declined in height as the Julian date increased, whereas the CAGO, ILBF, MSUN, and PPEA increased in height as the Julian date increased. The average plant heights increased each year for all 11 measured species ($p < 0.01$).

Plant densities interacted with species and the number of preceding harvests (Figure 3; $p < 0.01$). Overall, plant densities decreased ($p = 0.01$) from 2020 to 2021 but were similar ($p = 0.87$) between 2021 and 2022. Annual (PPEA) and biennial (BESU) species produced the greatest number of plants in 2020 but rapidly decreased ($p < 0.05$) to levels similar to the remaining 10 species after the first harvest. The purple coneflower ($p > 0.99$), LCOR ($p > 0.84$), OSUN ($p > 0.99$), and CUPP ($p > 0.99$) maintained consistent plant densities over the six harvests. Illinois bundleflower populations only differed ($p = 0.02$) between the preharvest and sixth harvest periods. The Canada goldenrod emerged in 2022 but was not present in previous years, whereas the PUPC and UPPC established at seeding but displayed consistently low persistence and population densities over the six harvests. The showy tick-trefoil maintained ($p > 0.28$) plant populations until the sixth harvest, at which point the populations declined ($p < 0.01$) substantially. Finally, the MSUN increased ($p < 0.01$) in population between the preharvest and second harvest periods and maintained ($p > 0.92$) consistent populations thereafter through the sixth harvest.

Table 3. Model results for the ANOVAs of forb characteristics during experiment evaluating 12 species of native forbs, 2020–2022, East Tennessee AgResearch and Education Center, Plant Science Unit, Knoxville, TN, USA.

Predictor	F	df	*p*-Value
Plant height			
Species	18.61	11	<0.01
Julian date	20.11	1	<0.01
Year	5.11	2	0.01
Species × Julian date	15.27	11	<0.01
Species × year	3.71	20	<0.01
Julian date × year	5.71	2	0.01
Species × Julian date × year	3.41	20	<0.01
Plant density			
Species	901.44	11	<0.01
Number of preceding harvests	284.51	6	<0.01
Species × number of preceding harvests	432.05	66	<0.01
Forage mass			
Species	29.95	11	<0.01
Year	1.97	1	0.17
Species × year	6.42	11	<0.01
Crude protein			
Species	5.12	10	<0.01
Neutral detergent fiber			
Species	12.27	9	<0.01
Acid detergent fiber			
Species	12.35	9	<0.01
Flowering length			
Species	9.96	9	<0.01
Median flowering date			
Species	55.41	9	<0.01
Flowering length	40.25	1	<0.01
Species × flowering length	22.84	9	<0.01

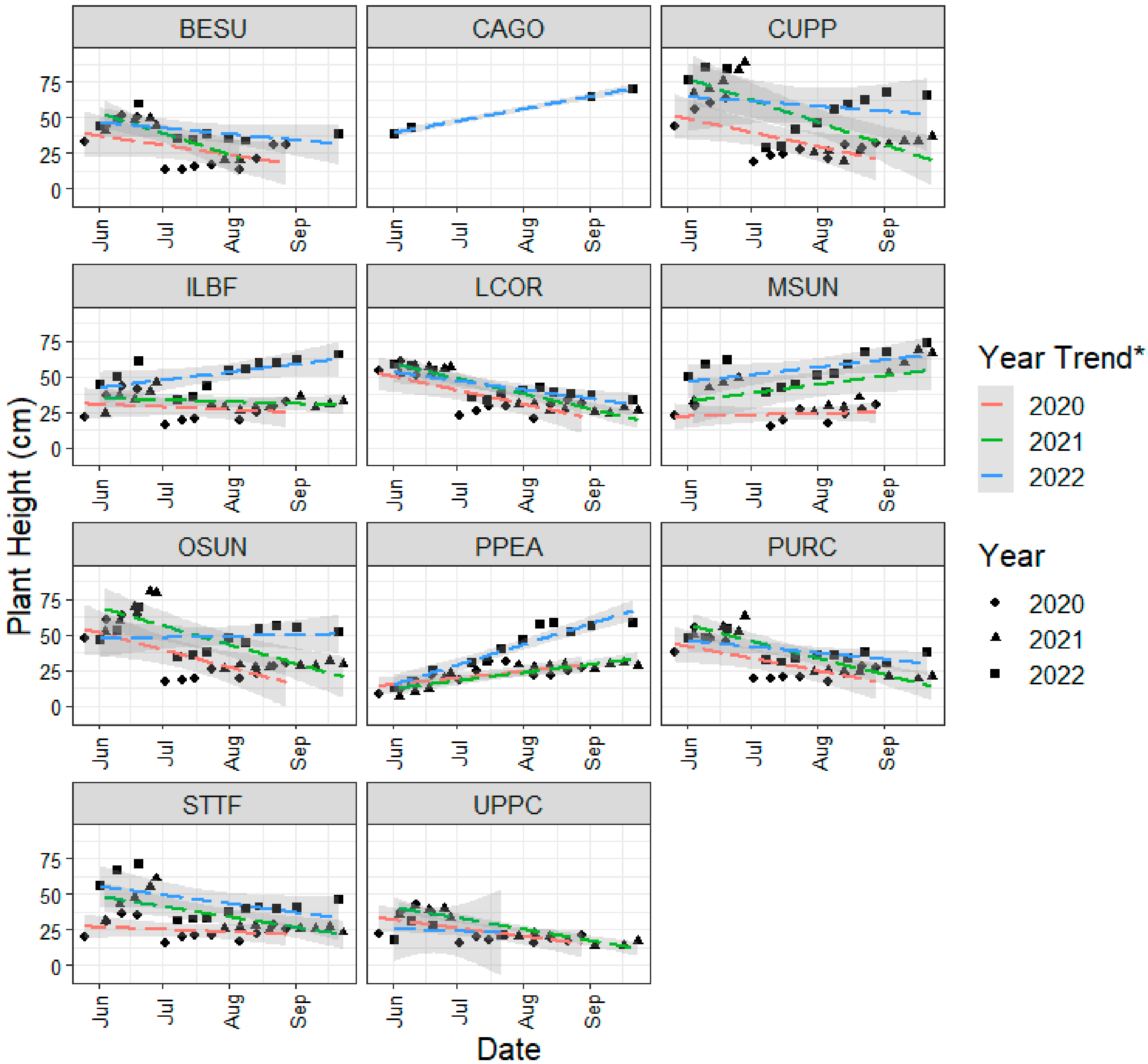

Figure 2. The plant height (cm) of 11 native forb species † subjected to repeated defoliation, 2020–2022, at the East Tennessee AgResearch and Education Center, Plant Science Unit, Knoxville, TN, USA. † Black-eyed Susan, BESU; Canada goldenrod, CAGO; cup plant, CUPP; Illinois bundleflower, ILBF; lanceleaf coreopsis, LCOR; Maximilian sunflower, MSUN; oxeye sunflower, OSUN; partridge pea, PPEA; purple coneflower, PURC; showy tick trefoil, STTF; upright prairie coneflower, UPPC. * Year trendlines are generated from a linear model incorporating species, Julian date, year (fixed), and replicate (random) and separated by species. Grey bands represent the 95% confidence interval around the estimated model.

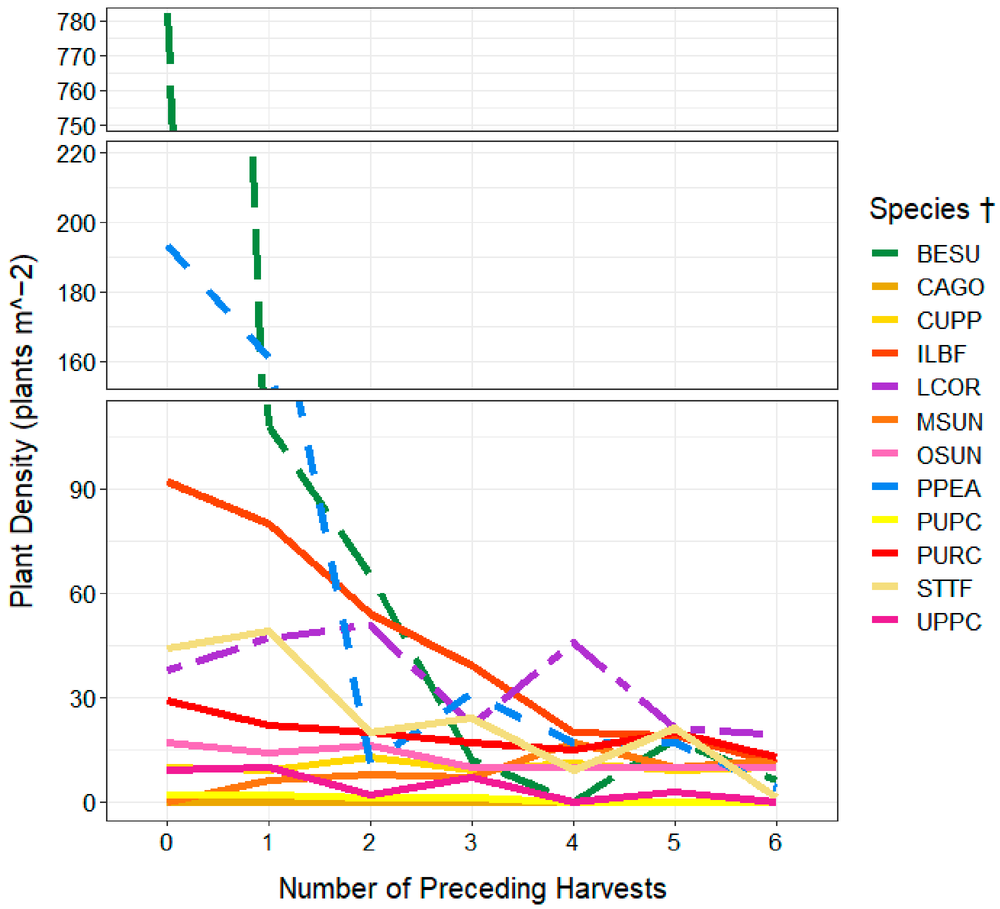

Figure 3. Plant densities (plants m^{-2}) of 12 native forb species subjected to repeated defoliation, 2020–2022, at the East Tennessee AgResearch and Education Center, Plant Science Unit, Knoxville, TN, USA. [26]. † Blue dashed line, annual (partridge pea, PPEA); green dashed line, biennial (black-eyed Susan, BESU); purple dashed line, short-lived perennial (lanceleaf coreopsis, LCOR); warm-colored, solid lines, perennial (Canada goldenrod, CAGO; cup plant, CUPP; Illinois bundleflower, ILBF; Maximilian sunflower, MSUN; oxeye sunflower, OSUN; purple prairie clover, PUPC; purple coneflower, PURC; showy tick-trefoil, STTF; upright prairie coneflower, UPPC).

3.3. Forage Mass

The forage mass was dependent on the year (Table 4; $p < 0.01$); however, the forage mass was only different between years for three of the eleven species. Two species, the MSUN ($p < 0.01$) and CUPP ($p < 0.01$), increased, and PPEA decreased ($p = 0.01$) in annual forage mass from 2020 to 2021. The cup plant was among the most productive forbs each year ($p < 0.05$), while the PUPC was the least productive ($p < 0.05$).

3.4. Forage Nutrient Composition

The mean forage nutrient composition varied among species (Table 5). The crude protein ranged from 105 to 189 g kg^{-1}, the NDF from 221 to 410 g kg^{-1}, and the ADF from 208 to 368 g kg^{-1}. The legumes PPEA, PUPC, STTF, and ILBF had some of the higher ($p < 0.05$) CP concentrations, while the BESU and LCOR were among the forbs with the lowest ($p < 0.05$) mean CP. The black-eyed Susan and UPPC were among the forbs with the highest ($p < 0.05$) NDF and ADF concentrations, while the PPEA and CUPP were among those with the lowest ($p < 0.05$) fiber concentrations. Overall, the fiber content was low for all species, never exceeding 410 (NDF) and 368 (ADF) g kg^{-1} for any species.

Table 4. The annual total forage mass (kg ha^{-1} DM [†]) of 12 native forb species subjected to repeated defoliation, 2020–2021, at the East Tennessee AgResearch and Education Center, Plant Science Unit, Knoxville, TN, USA.

Species	Year	
	2020	2021
	kg ha^{-1} DM	
BESU	3374	1926
CAGO	-	-
CUPP	7248 ^{b} *	14,803 ^{a}
ILBF	3663	2016
LCOR	3177	4564
MSUN	773 ^{b}	5242 ^{a}
OSUN	3524	3623
PPEA	1250 ^{a}	9 ^{b}
PUPC	6	2
PURC	4284	4719
STTF	627	957
UPPC	823	1747

[†] Dry matter, DM; black-eyed Susan, BESU; Canada goldenrod, CAGO; cup plant, CUPP; Illinois bundleflower, ILBF; lanceleaf coreopsis, LCOR; Maximilian sunflower, MSUN; oxeye sunflower, OSUN; partridge pea, PPEA; purple prairie clover, PUPC; purple coneflower, PURC; showy tick-trefoil, STTF; upright prairie coneflower, UPPC. * Means within a row without a common letter differ based on Tukey's HSD test ($p < 0.05$).

Table 5. The forage nutritive composition of 11 native forb species subjected to repeated defoliation, 2020–2022, at the East Tennessee AgResearch and Education Center, Plant Science Unit, Knoxville, TN, USA.

Species [†]	Forage Nutrient Measures		
	CP	NDF	ADF
	g kg^{-1} DM		
BESU	107 c *	410 ^{a}	368 ^{a}
CAGO [§]	-	-	-
CUPP	135 ^{bc}	221 ^{d}	217 ^{d}
ILBF	143 ^{abc}	254 ^{bcd}	225 ^{bcd}
LCOR	105 ^{c}	320 ^{abc}	282 ^{abc}
MSUN	142 ^{abc}	306 ^{abc}	294 ^{ab}
OSUN	142 ^{abc}	277 ^{bcd}	234 ^{bcd}
PPEA	189 ^{a}	235 ^{cd}	208 ^{cd}
PUPC	168 ^{abc}	-	-
PURC	126 ^{bc}	326 ^{abc}	278 $^{a–d}$
STTF	154 ^{ab}	348 ^{ab}	316 ^{a}
UPPC	142 ^{abc}	404 ^{a}	353 ^{a}
Mean	141	310	278

[†] Black-eyed Susan, BESU; Canada goldenrod, CAGO; cup plant, CUPP; Illinois bundleflower, ILBF; lanceleaf coreopsis, LCOR; Maximilian sunflower, MSUN; oxeye sunflower, OSUN; partridge pea, PPEA; purple prairie clover, PUPC; purple coneflower, PURC; showy tick-trefoil, STTF; upright prairie coneflower, UPPC; crude protein, CP; neutral detergent fiber, NDF; acid detergent fiber, ADF; dry matter, DM. * Means within a column without a common letter differ based on Tukey's HSD test ($p < 0.05$). [§] The CAGO and PUPC lacked sufficient forage mass for analysis.

3.5. Flowering Characteristics

Species transitioned through different maturity stages at different times of the year (Figure 4) and displayed flowers for varying lengths (Figure 5; $p < 0.05$). The purple coneflower (106 days, 95% CI: 98, 113), LCOR (95 days, 95% CI: 87, 103), STTF (89 days, 95% CI: 79, 98), and OSUN (88 days, 95% CI: 78, 98) flowered the longest ($p < 0.05$) of the 10 species observed flowering. The upright prairie coneflower (53 days, 95% CI: 34, 67), CUPP (56 days, 95% CI: 24, 75), and ILBF (53 days, 95% CI: 31, 69) were among the species with the shortest ($p < 0.05$) duration of flowering.

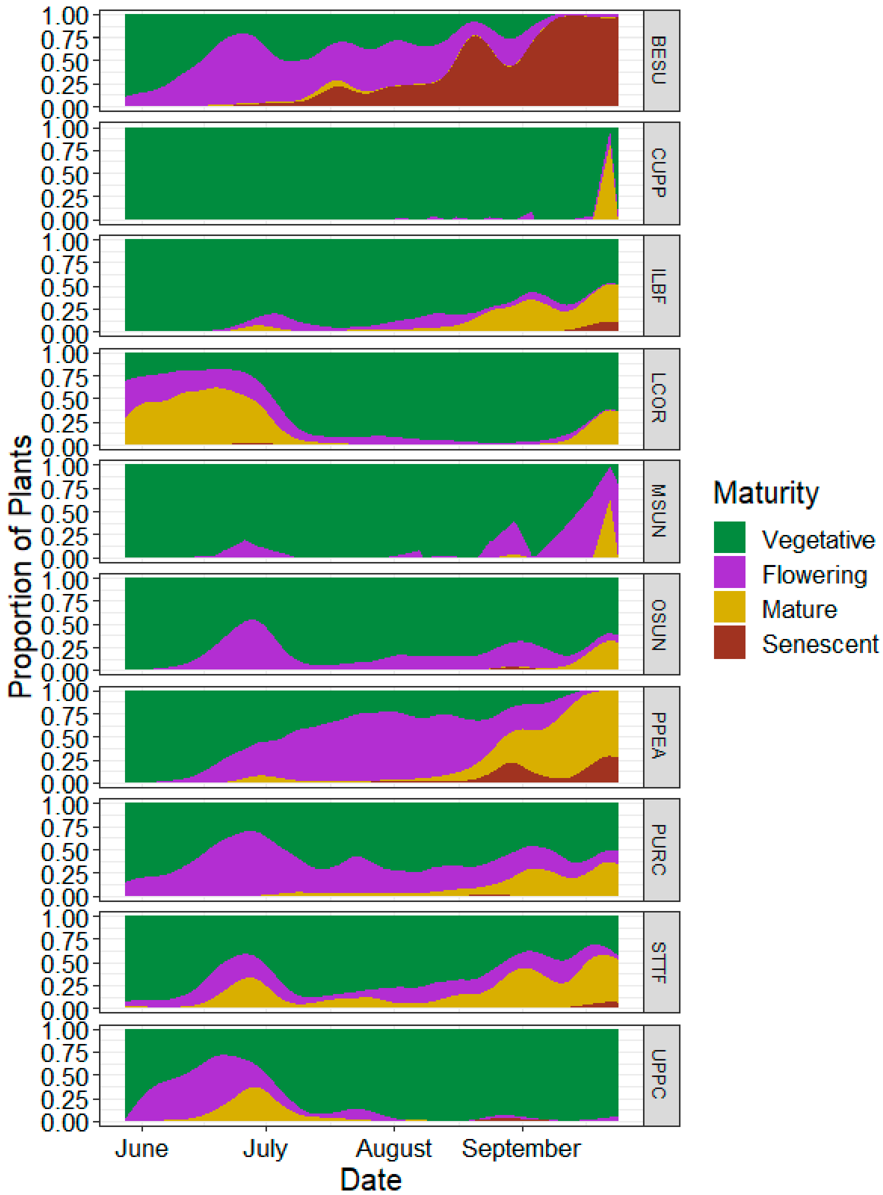

Figure 4. The proportions of four different plant maturity stages for 10 native forb species † throughout the growing season averaged over 2020–2022 at the East Tennessee AgResearch and Education Center, Plant Science Unit, Knoxville, TN, USA. † Black-eyed Susan, BESU; cup plant, CUPP; Illinois bundleflower, ILBF; lanceleaf coreopsis, LCOR; Maximilian sunflower, MSUN; oxeye sunflower, OSUN; partridge pea, PPEA; purple coneflower, PURC; showy tick-trefoil, STTF; upright prairie coneflower, UPPC.

The median flowering date interacted with the species and flowering period length (Figure 6; $p < 0.01$). Species with longer flowering periods (e.g., the PURC, LCOR) had earlier ($p < 0.05$) median flowering dates compared to species with shorter flowering periods (e.g., the CUPP, ILBF).

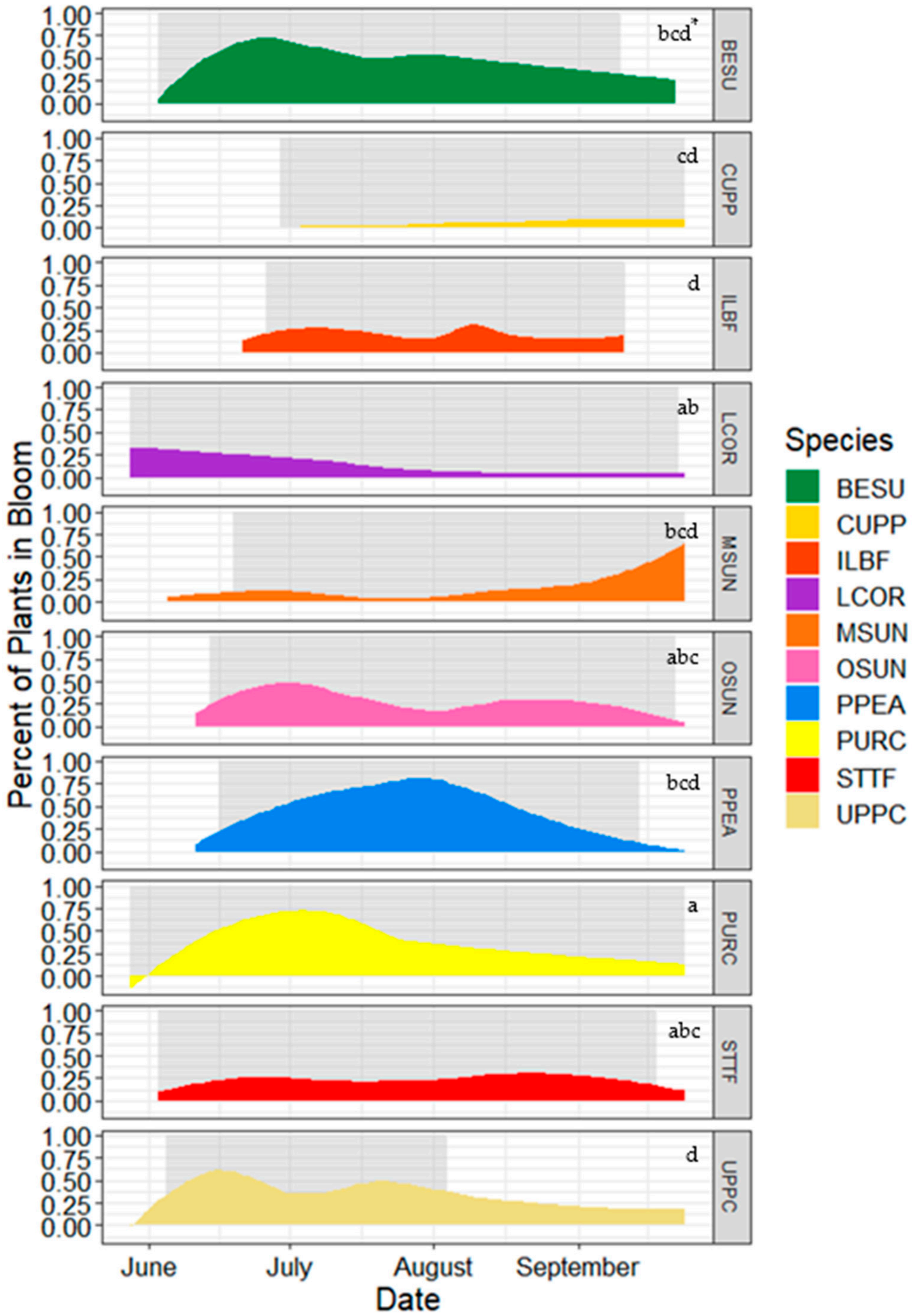

Figure 5. The mean flowering period length (grey) and proportion of plants flowering (colored bands) for 10 native forb species † observed 2020–2022 at the East Tennessee AgResearch and Education Center, Plant Science Unit, Knoxville, TN, USA. † Black-eyed Susan, BESU; cup plant, CUPP; Illinois bundleflower, ILBF; lanceleaf coreopsis, LCOR; Maximilian sunflower, MSUN; oxeye sunflower, OSUN; partridge pea, PPEA; purple coneflower, PURC; showy tick-trefoil, STTF; upright prairie coneflower, UPPC. * The mean flowering period lengths (days; grey) among species without a common letter differ based on Tukey's HSD test ($p < 0.05$).

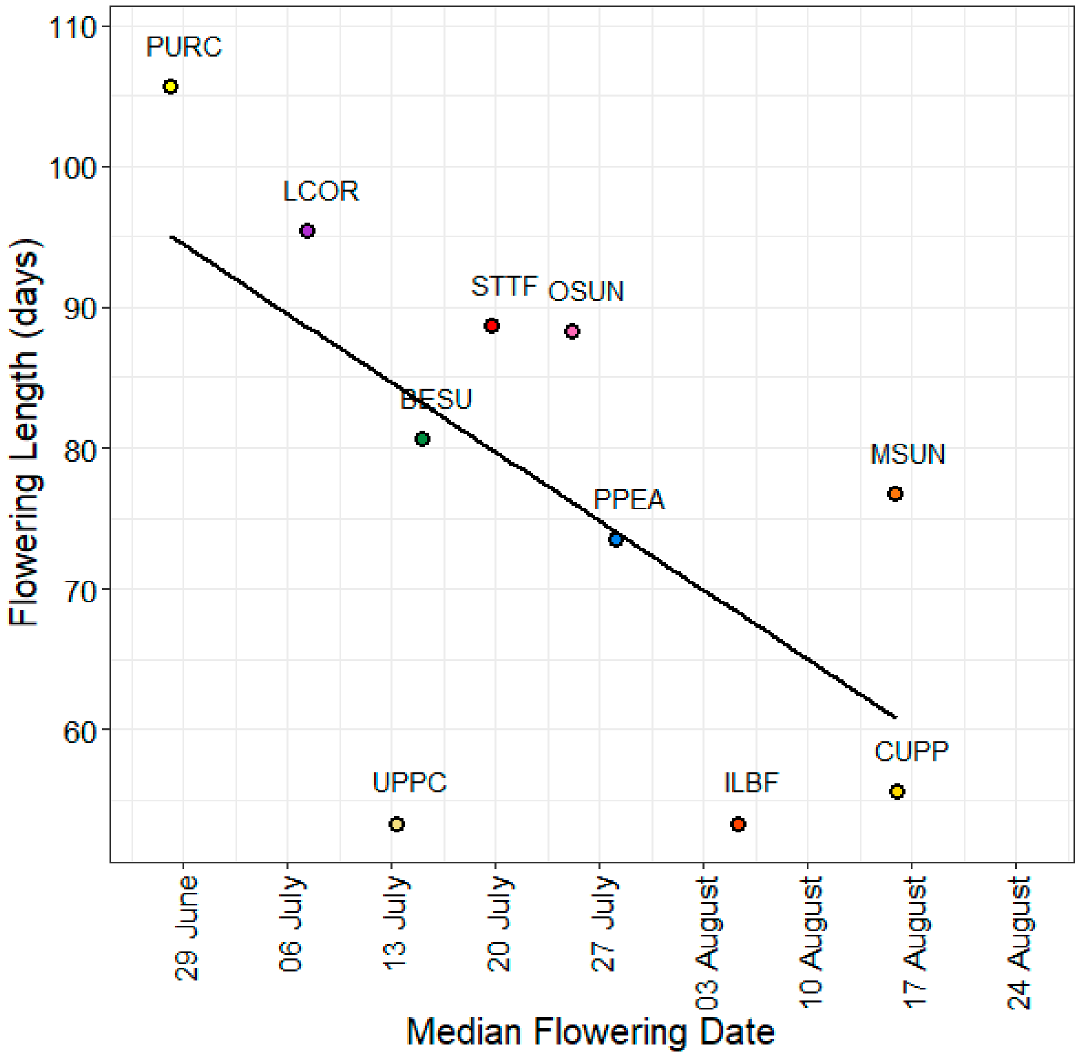

Figure 6. The median flowering date in relation to the flowering length for 10 native forb species [†], 2020–2022, at the East Tennessee AgResearch and Education Center, Plant Science Unit, Knoxville, TN, USA. [†] Black-eyed Susan, BESU; cup plant, CUPP; Illinois bundleflower, ILBF; lanceleaf coreopsis, LCOR; Maximilian sunflower, MSUN; oxeye sunflower, OSUN; partridge pea, PPEA; purple coneflower, PURC; showy tick-trefoil, STTF; upright prairie coneflower, UPPC.

4. Discussion

Plant persistence, forage characteristics, and flowering patterns varied among the native forb species we evaluated. Despite these differences, multiple species exhibited persistent plant populations and produced high-quality forage and long-lasting floral resources throughout the growing season.

4.1. Plant Persistence

Plant persistence to repeated defoliation is a major consideration in establishing and maintaining a diverse pasture. The incorporation of native forbs into native grass pastures has the potential to provide forage and floral resources while also populating the gaps that naturally occur between native bunchgrasses. Persistent soil cover can reduce labor and herbicide requirements in future growing seasons by precluding undesirable plants from becoming established. Conversely, plants with poor vigor or a low tolerance to defoliation are likely to lead to increased weed encroachment [27–30]. Some defoliation, however, can improve stand performance, persistence, and flowering presence compared to ungrazed prairies [16]. Additionally, persistent, diverse cover can provide valuable resources for birds [6,7] and browsers [4] during peak life history events.

Plant populations declined markedly for the annual (PPEA) and biennial (BESU) species in response to defoliation, and their persistence was largely reproductive (i.e., reseeding quantity and seedling vigor) and environmentally (i.e., soil–seed contact and drought) driven. True annual species only persist for one growing season, and populations rely on reseeding each season, whereas biennials grow for two seasons and are also prolific reseeders, particularly when their rosettes have the opportunity to mature and, thus, increase their capacity to flower [15]. The decline in PPEA populations likely occurred due to poor reseeding, poor soil–seed contact, and drought conditions, despite light soil scarification each season to encourage germination and recruitment. Including PPEA into pastures with active grazers could produce different results due to natural disturbance from hoof traffic, changes in thatch and canopy cover, and grazer preference [31]. After a decline in populations, the BESU repopulated by reseeding but experienced poor vigor following harvests each season, though the remaining plants grew taller each year. Poor persistence does not eliminate a forb's value in a diverse plant community. Including an initially vigorous annual or biennial can act as a companion crop for grass or forb seedlings [32], provide soil cover and weed suppression while the remaining seeded species undergo stratification, or improve soil nutrients through nitrogen fixation (e.g., the PPEA). These benefits are in addition to the abundance of floral resources that annuals and biennials provide during their first or second growing season.

Perennials demonstrated varying persistence trends in response to repeated defoliation. The purple prairie clover and CAGO were not persistent and provided minimal forage mass when present. The seed size, seeding depth (i.e., >1 cm), and competition with thatch early in the season likely hampered the establishment of these two species. Taller growing forbs like the CUPP and MSUN increased in plant height over the three growing seasons. These two species also maintained plant populations and substantially increased forage mass during the first two seasons. Although ground cover and persistence are major factors when selecting appropriate species for pasture enhancement, the CUPP and MSUN displayed aggressive tillering and increased dominance. The Maximilian sunflower, in particular, increased tillering following defoliation, and single plants often covered up to 1 m^2 after three growing seasons. When incorporating either of these two species into pastures, the seeding rates should be carefully considered to minimize overpopulation and competition for available resources. Lanceleaf coreopsis and the PURC and OSUN produced similarly to one another over the two growing seasons and maintained their populations over the six defoliation events, indicating a great deal of tolerance to defoliation while providing sufficient forage mass for grazers. The upright prairie coneflower established well initially but experienced poor persistence to repeated defoliation, and plants were consistently short, a factor that may make this species less competitive. Two legumes, the STTF and ILBF, both established well and declined in population but still persisted over three seasons, making them suitable perennial legume options. Cool-season species have demonstrated poor establishment and persistence in native warm-season grass pastures [33] due to seasonal differences and poor competition during the summer. The warm-season forb species evaluated here that demonstrate long-term persistence may be more suited to being interseeded into native grass stands due to their increased productivity and competition during the summer.

Overall, most species persisted over three growing seasons; however, the LCOR, ILBF, OSUN, PURC, CUPP, and MSUN were the most vigorous and maintained consistent populations. These species likely maintained populations due to high canopy heights (the CUPP and MSUN), an increase in canopy height after three seasons (the ILBF), prolific reseeding (the LCOR), or increased tillering (the PURC, OSUN, and MSUN). Additionally, moderate defoliation can improve stand performance and persistence by increasing both tillering and root growth in actively growing plants [29,34]. The persistent forbs not only maintained populations, but likely improved in root mass and tillering after defoliation.

Persistent forbs in a diverse grassland can also improve soil filtration [35], net primary productivity, and nitrogen retention and support a wider array of soil microbes [36].

4.2. Forage Characteristics

In addition to plant persistence, forage characteristics are pivotal in determining the value that these species contribute to pastures. Forbs with limited productivity like the PUPC, CAGO, and STTF would likely not make an important contribution to forage mass in an interseeded pasture. Tall (CUPP and MSUN) and moderately tall (PURC, OSUN, UPPC, and LCOR) forbs maintained or increased forage mass over the two growing seasons, suggesting persistence not only in plant populations but biomass quantity. Donkor et al. [17] demonstrated that defoliation frequency and the start of defoliation during the growing season interacted and contributed to the complexity of forb responses to defoliation. The life history of forbs and their maturity cycle strongly influence the forage mass produced at each defoliation, as well as their ability to regenerate mass afterwards [16]. Forbs that have already produced seed, such as the LCOR in mid-June, may not regrow as vigorously as a previously vegetative forb when defoliated at that stage.

In addition to the importance of overall productivity as measured by forage mass, the forage nutritive composition plays an important role in the selection of forages to interseed into pastures. Native warm-season grasses in mixed stands of big bluestem (*Andropogon gerardii* Vitman), Indiangrass (*Sorghastrum nutans* (L.) Nash), and little bluestem (*Schizachyrium scoparium* (Michx.) Nash) averaged 81 to 147 g kg^{-1} of CP, 557 to 683 g kg^{-1} of NDF, and 347 to 454 g kg^{-1} of ADF [37]. Selecting forbs with a higher CP and lower NDF and ADF to interseed could improve the forage quality produced within the stand. A growing 227 kg steer gaining 0.9 kg d^{-1} requires a daily intake of 128 g kg^{-1} CP and will consume a daily average of 1.5 to 2.5% of their body weight (BW) in pasture on a dry matter basis [38,39]. Larger steers and those with higher rates of gain require more CP for muscle gain, a threshold that may not be met by grasses in later maturity stages in July and August. Interseeded forages could bridge the nutrient gap, and most of the forbs we assessed appear to be able to increase CP concentrations while also providing forage low in NDF and ADF. Rations comprising 350 g kg^{-1} NDF reduced intake in cattle compared to rations comprising 250 g kg^{-1} NDF [40]. Therefore, low-fiber forages like these native forbs can provide high-quality nutrition without compromising intake during a period when mature grasses may already reduce intake. Native forbs can play a similar role to that which the purple top turnip (*Brassica rapa* subsp. rapa L.), daikon radish (*Raphanus sativus* subsp. *longipinnatus* L.), berseem clover (*Trifolium alexandrinum* L.), and red clover (*Trifolium pratense* L.) play in cool-season forage systems, by improving the forage quality and quantity throughout their respective seasons. Cool-season forbs provide similar nutrient composition to these warm-season native forbs (141–350 g kg^{-1} CP and 21–33 g kg^{-1} NDF [41,42]) and have been shown to maintain cattle productivity while also providing ground cover [43].

4.3. Flowering Patterns

Forbs that persist and may be suitable for grazing can also play key roles in floral diversity. Grasses are wind-pollinated and provide minimal floral resources for at-risk pollinator populations. The inclusion of flowering forbs in grass pastures can increase the floral resources both in floral density and in floral duration throughout the growing season. Of the species evaluated, the PURC flowered the longest, with some of the greatest bloom densities, making it a valuable addition to improve floral densities over much of the summer. To extend the flowering season into late summer and early fall, the CUPP and MSUN appear to be good options. The median flowering date differed among species and was also related to the flowering period length. Early blooming species tended to flower longer, whereas critical fall-blooming species flowered for shorter periods. Selecting a diverse collection of forbs to flower not only at different dates but with overlapping blooming periods could improve the stability and quantity of floral resources. A mixture of the LCOR, PURC, BESU, OSUN, and CUPP or MSUN should provide blooms throughout the summer. Native bees, some of the primary visitors to native forbs, have shown a preference for the MSUN, OSUN, PURC, and UPPC [18] over introduced species like the red and white clover (*Trifolium repens* L.), making those forbs even more desirable for pollinators. Lastly, the inclusion of a diverse set of forbs can encourage and support a more diverse population of pollinators [14] and grassland birds [44] that benefit from diverse floral and seed resources, improving the overall biodiversity in the system.

4.4. Cost-Effective Forbs

Incorporating new forages into a pasture can be costly, and plant establishment is not consistent year to year. Although this study did not evaluate the cost effectiveness of the measured species, Simanonok et al. [18] found many of the better performing forbs to be cost-effective options that combine high flowering potential (e.g., high flower detection) and low seed cost (<USD 61.20 100,000 seeds^{-1}). Based on 2020 prices for the legumes, PPEA and PUPC were more cost-effective than STTF and averaged USD 31.00 and USD 14.50 100,000 seeds^{-1}, respectively. The upright prairie coneflower, BESU, PURC, OSUN, and MSUN were also cost effective and ranged from USD 1.80 to USD 39.60 100,000 seeds^{-1}. Forbs with lower cost thresholds combat the risk of incorporating novel forages into a stand, as new adopters are likely to include a diversity of species. Additionally, persistent species and those that reseed (e.g., the LCOR) reduce the need for reseeding, thereby decreasing inputs past establishment and further improving cost effectiveness.

4.5. Limitations and Further Study

This study illustrates the basic forage and blooming characteristics of 12 native forbs. However, the evaluation taking place at just one study location suggests that we should be cautious in applying these results in environments with considerably different soil and climatic conditions. Also, we did not evaluate these same forbs in mixed swards, which would be common for pastures. In such conditions, the competitive capacity of these species may have altered their productivity. The lack of measured forage mass in 2022 may have led to an underestimate of the persistence of some species (e.g., the LCOR and STTF). Although the data gathered can provide general recommendations for these species, studies expanding the length of observations and the number and diversity of study sites would further refine recommendations for the use of these species in various pasture environments.

5. Conclusions

Native forbs present an opportunity to enhance grass pastures and can provide forage for cattle, an enhanced wildlife habitat, and floral resources for at-risk pollinators. Annuals (the PPEA) and biennials (the BESU) provided large amounts of high-quality forage and flowers during the first year and provided valuable ground cover before other species established. The tall-growing MSUN and CUPP took a couple of years to establish hardy rosettes, but increased in forage mass, produced high-quality forage, and developed blooms during the critical early fall season. Lanceleaf coreopsis behaved like a short-lived perennial but, through prolific reseeding, produced consistent forage mass and a high density of early-season flowers. The purple coneflower and OSUN produced high-quality, consistent forage mass and developed flowers during the mid-season. Based on our study, including a blend of the BESU, ILBF, PPEA, LCOR, PURC, OSUN, and MSUN or CUPP into pasture would produce high-quality forage throughout the grazing season and allow for floral resources to be present from May to September for insect pollinators.

Author Contributions: Conceptualization, J.D.R., K.J.S. and P.D.K.; Methodology, J.L.P., E.B., J.D.R., K.J.S. and P.D.K.; Formal analysis, J.L.P.; Investigation, J.L.P., E.B., J.D.R. and K.J.S.; Data curation, J.L.P., E.B. and K.J.S.; Writing—original draft, J.L.P.; Writing—review & editing, E.B., J.D.R., K.J.S. and P.D.K.; Visualization, J.L.P. and P.D.K.; Project administration, P.D.K.; Funding acquisition, P.D.K. All authors have read and agreed to the published version of the manuscript.

Funding: This research was funded by the USDA Hatch Project grant number TEN00547, the University of Tennessee Foundation, and Ernst Conservation Seeds.

Data Availability Statement: Data presented at this paper are contained within the manuscript.

Conflicts of Interest: The authors declare no conflict of interest.

References

1. The University of Texas at Austin Lady Bird Johnson Wildflower Center. Available online: https://www.wildflower.org/ (accessed on 23 February 2022).
2. Harper, C.A. Strategies for Managing Early Succession Habitat for Wildlife. *Weed Technol.* **2007**, *21*, 932–937. [CrossRef]
3. Jones, P.D.; Mixon, M.R.; Demarais, S. Habitat Quality Following Mid-Rotation Treatment in Conservation Reserve Program Pines. *J. Wildl. Manag.* **2009**, *73*, 1166–1173. [CrossRef]
4. Ulappa, A.C.; Shipley, L.A.; Cook, R.C.; Cook, J.G.; Swanson, M.E. Silvicultural Herbicides and Forest Succession Influence Understory Vegetation and Nutritional Ecology of Black-Tailed Deer in Managed Forests. *For. Ecol. Manag.* **2020**, *470–471*, 118216. [CrossRef]
5. Yeiser, J.M.; Baxley, D.L.; Robinson, B.A.; Morgan, J.J. Using Prescribed Fire and Herbicide to Manage Rank Native Warm Season Grass for Northern Bobwhite. *J. Wildl. Manag.* **2015**, *79*, 69–76. [CrossRef]
6. Peters, D.C.; Brooke, J.M.; Tanner, E.P.; Unger, A.M.; Keyser, P.D.; Harper, C.A.; Clark, J.D.; Morgan, J.J. Impact of Experimental Habitat Manipulation on Northern Bobwhite Survival. *J. Wildl. Manag.* **2015**, *79*, 605–617. [CrossRef]
7. Pollentier, C.D.; Lutz, R.S.; Drake, D. Female Wild Turkey Habitat Selection in Mixed Forest-Agricultural Landscapes. *J. Wildl. Manag.* **2017**, *81*, 487–497. [CrossRef]
8. van Engelsdorp, D.; Evans, J.D.; Saegerman, C.; Mullin, C.; Haubruge, E.; Nguyen, B.K.; Frazier, M.; Frazier, J.; Cox-Foster, D.; Chen, Y.; et al. Colony Collapse Disorder: A Descriptive Study. *PLoS ONE* **2009**, *4*, e6481. [CrossRef]
9. Potts, S.G.; Biesmeijer, J.C.; Kremen, C.; Neumann, P.; Schweiger, O.; Kunin, W.E. Global Pollinator Declines: Trends, Impacts and Drivers. *Trends Ecol. Evol.* **2010**, *25*, 345–353. [CrossRef]
10. Shackelford, G.; Steward, P.R.; Benton, T.G.; Kunin, W.E.; Potts, S.G.; Biesmeijer, J.C.; Sait, S.M. Comparison of Pollinators and Natural Enemies: A Meta-Analysis of Landscape and Local Effects on Abundance and Richness in Crops. *Biol. Rev.* **2013**, *88*, 1002–1021. [CrossRef]
11. Weiner, C.N.; Werner, M.; Linsenmair, K.E.; Blüthgen, N. Land-Use Impacts on Plant-Pollinator Networks: Interaction Strength and Specialization Predict Pollinator Declines. *Ecology* **2014**, *95*, 466–474. [CrossRef]
12. Grab, H.; Branstetter, M.G.; Amon, N.; Urban-Mead, K.R.; Park, M.G.; Gibbs, J.; Blitzer, E.J.; Poveda, K.; Loeb, G.; Danforth, B.N. Agriculturally Dominated Landscapes Reduce Bee Phylogenetic Diversity and Pollination Services. *Science (1979)* **2019**, *363*, 282–284. [CrossRef] [PubMed]
13. Keyser, P.D.; Buehler, D.A.; Fike, J.H.; Finke, D.L.; Fuhlendorf, S.D.; Martin, J.A.; Naumann, H.D.; Smith, S.R. The Birds and the Bees: Producing Beef and Conservation Benefits on Working Grasslands. *Agronomy* **2022**, *12*, 1934. [CrossRef]
14. Grass, I.; Albrecht, J.; Jauker, F.; Diekötter, T.; Warzecha, D.; Wolters, V.; Farwig, N. Much More than Bees-Wildflower Plantings Support Highly Diverse Flower-Visitor Communities from Complex to Structurally Simple Agricultural Landscapes. *Agric. Ecosyst. Environ.* **2016**, *225*, 45–53. [CrossRef]
15. Bjørn, M.C.; Weiner, J.; Kollmann, J.; Ørgaard, M. Landscape and Urban Planning Increasing Local Biodiversity in Urban Environments: Community Development in Semi-Natural Species-Rich Forb Vegetation. *Landsc. Urban Plan* **2019**, *184*, 23–31. [CrossRef]
16. Williams, D.W.; Jackson, L.L.; Smith, D.D. Effects of Frequent Mowing on Survival and Persistence of Forbs Seeded into a Species-Poor Grassland. *Restor. Ecol.* **2007**, *15*, 24–33. [CrossRef]
17. Donkor, N.T.; Bork, E.W.; Hudson, R.J. Defoliation Regime Effects on Accumulated Season-Long Herbage Yield and Quality in Boreal Grassland. *J. Agron. Crop. Sci.* **2003**, *189*, 39–46. [CrossRef]
18. Simanonok, S.C.; Otto, C.R.V.; Iovanna, R. Forbs Included in Conservation Seed Mixes Exhibit Variable Blooming Detection Rates and Cost-Effectiveness: Implications for Pollinator Habitat Design. *Restor. Ecol.* **2022**, *30*, e13657. [CrossRef]
19. Keyser, P. *Native Grass Forages for the Eastern U.S.*; The University of Tennessee Institute of Agriculture: Knoxville, TN, USA, 2021.
20. U.S. Drought Monitor. Available online: https://droughtmonitor.unl.edu/CurrentMap/StateDroughtMonitor.aspx?fips_47093 (accessed on 18 November 2023).
21. McIntosh, D.; Aderson-Husmoen, B.J.; Kern-Lunbery, R.; Goldblatt, P.; Lemus, R.; Griggs, T.; Bauman, L.; Boone, S.; Shewmaker, G.; Teutsch, C. *Guidelines for Optimal Use of NIRSC Forage and Feed Calibrations in Membership Laboratories*, 2nd ed.; The University of Tennessee Press: Knoxville, TN, USA, 2022.
22. AOAC. Method 990.03: Protein (Crude) in Animal Feed: Combustion Method. In *Official Methods of Analysis*; AOAC International: Gaithersburg, MD, USA, 2010; ISBN 0935584544.
23. Van Soest, P.J.; Robertson, J.B.; Lewis, B.A. Methods for Dietary Fiber, Neutral Detergent Fiber, and Nonstarch Polysaccharides in Relation to Animal Nutrition. *J. Dairy Sci.* **1991**, *74*, 3583–3597. [CrossRef]
24. Goering, H.K.; Van Soest, P.J. *Forage Fiber Analyses (Apparatus, Reagents, Procedures, and Some Applications)*; U.S. Government Publishing Office: Washington, DC, USA, 1970.

25. AOAC. AOAC Official Method 973.18 Fiber (Acid Detergent) and Lignin (H2SO4) in Animal Feed. In *Official Methods of Analysis*; AOAC International: Gaithersburg, MD, USA, 2005; ISBN 0935584544.
26. Xu, S.; Chen, M.; Feng, T.; Zhan, L.; Zhou, L.; Yu, G. Use Ggbreak to Effectively Utilize Plotting Space to Deal with Large Datasets and Outliers. *Front. Genet.* **2021**, *12*, 2122. [CrossRef]
27. Damhoureyeh, S. Effects of Simulated Grazing (Clipping) on Plant Population Responses and Resource Allocation Patterns in Semi-Arid Environment. *Pak. J. Bot.* **2017**, *49*, 981–986.
28. Ditomaso, J.M. Invasive Weeds in Rangelands: Species, Impacts, and Management. *Weed Sci.* **2000**, *48*, 255–265. [CrossRef]
29. Tracy, B.F.; Sanderson, M.A. Forage Productivity, Species Evenness and Weed Invasion in Pasture Communities. *Agric. Ecosyst. Environ.* **2004**, *102*, 175–183. [CrossRef]
30. Tracy, B.F.; Renne, I.J.; Gerrish, J.; Sanderson, M.A. Effects of Plant Diversity on Invasion of Weed Species in Experimental Pasture Communities. *Basic Appl. Ecol.* **2004**, *5*, 543–550. [CrossRef]
31. Deak, A.; Hall, M.H.; Sanderson, M.A. Grazing Schedule Effect on Forage Production and Nutritive Value of Diverse Forage Mixtures. *Agron. J.* **2009**, *101*, 408–414. [CrossRef]
32. Richwine, J.D.; Keyser, P.D.; Hancock, D.W.; Ashworth, A.J. Using a Browntop Millet Companion Crop to Aid Native Grass Establishment. *Agron. J.* **2021**, *113*, 3210–3221. [CrossRef]
33. Keyser, P.D.; Holcomb, E.D.; Lituma, C.M.; Bates, G.E.; Waller, J.C.; Boyer, C.N.; Travis Mulliniks, J. Forage Attributes and Animal Performance from Native Grass Inter-Seeded with Red Clover. *Agron. J.* **2016**, *108*, 373–383. [CrossRef]
34. Tracy, B.F.; Davis, A.S. Weed Biomass and Species Composition as Affected by an Integrated Crop-Livestock System. *Crop. Sci.* **2009**, *49*, 1523–1530. [CrossRef]
35. Liu, Y.; Miao, H.T.; Chang, X.; Wu, G.L. Higher Species Diversity Improves Soil Water Infiltration Capacity by Increasing Soil Organic Matter Content in Semiarid Grasslands. *Land Degrad Dev.* **2019**, *30*, 1599–1606. [CrossRef]
36. Thompson, G.L.; Kao-Kniffin, J. Diversity Enhances NPP, N Retention, and Soil Microbial Diversity in Experimental Urban Grassland Assemblages. *PLoS ONE* **2016**, *11*, e0155986. [CrossRef]
37. Brazil, K.A.; Keyser, P.D.; Bates, G.E.; Saxton, A.M.; Holcomb, E.D. Continuous Grazing of Mixed Native Warm-Season Grass in the Fescue Belt. *Agron. J.* **2020**, *112*, 5067–5080. [CrossRef]
38. Rushing, J.B.; Maples, J.G.; Rivera, J.D.; Lyles, J.C. Early-Season Grazing of Native Grasses Offers Potential Profitable Benefit. *Agron. J.* **2020**, *112*, 1057–1067. [CrossRef]
39. National Research Council. *Nutrient Requirements of Beef Cattle*, 8th ed.; National Academy Press: Washington, DC, USA, 2016; ISBN 9780309317023.
40. Dado, R.G.; Allen, M.S. Intake Limitations, Feeding Behavior, and Rumen Function of Cows Challenged with Rumen Fill from Dietary Fiber or Inert Bulk. *J. Dairy Sci.* **1995**, *78*, 118–133. [CrossRef] [PubMed]
41. Prigge, J.L.; Sheaffer, C.C.; Jungers, J.M.; Jaqueth, A.L.; Lochner, H.L.; Martinson, K.L. Forage Characteristics and Grazing Preference of Cover Crops in Equine Pasture Systems. *J. Equine Vet. Sci.* **2021**, *103*, 103663. [CrossRef] [PubMed]
42. Sousa, D.O.; Hansen, H.H.; Hallin, O.; Nussio, L.G.; Nadeau, E. A Two-Year Comparison on Nutritive Value and Yield of Eight Lucerne Cultivars and One Red Clover Cultivar. *Grass Forage Sci.* **2020**, *75*, 76–85. [CrossRef]
43. Brunsvig, B.R.; Smart, A.J.; Bailey, E.A.; Wright, C.L.; Grings, E.E.; Brake, D.W. Effect of Stocking Density on Performance, Diet Selection, Total-Tract Digestion, and Nitrogen Balance among Heifers Grazing Cool-Season Annual Forages. *J. Anim. Sci.* **2017**, *95*, 3513–3522. [CrossRef]
44. Vickery, J.A.; Feber, R.E.; Fuller, R.J. Arable Field Margins Managed for Biodiversity Conservation: A Review of Food Resource Provision for Farmland Birds. *Agric. Ecosyst. Environ.* **2009**, *133*, 1–13. [CrossRef]