**Bird Species Observation Analysis**

**Forest Data Analysis:**

**1. Species Frequency per Site:**

The analysis of bird abundance and diversity across forest sites shows Prince William Forest Park (PRWI) and C&O Canal Historical Park (CHOH) as hotspots. PRWI has the highest bird count, suggesting favorable habitat or bird activity, while CHOH leads in species richness, indicating high biodiversity. In contrast, Wolf Trap National Park (WOTR) records the lowest abundance and diversity, possibly due to ecological or urban constraints. Despite high numbers at PRWI, lower species diversity suggests species dominance. These patterns call for customized conservation efforts, focusing on biodiversity-rich parks like CHOH and investigating challenges at WOTR.

**2. Species Behavior and Detection Patterns:**

Birds were more frequently observed within 50 meters (4302) than at 50–100 meters (4142), reflecting easier detection up close. Singing was the most common behavior (5426 detections), followed by calling (2675) and rare visual sightings (343), likely due to limited visibility. Most species were detected early (0–2.5 mins), though Wood Thrush and Scarlet Tanager were detected later, and species like the American Crow were consistent across intervals. Visit 1 (4317 detections) and Visit 2 (4127) showed similar activity, indicating stable bird presence.

**3. Environmental Influence:**

Clear and partly cloudy skies and low wind (0–3 mph) favor bird observations and species richness. Fog and high winds reduce detectability and activity. Singing remains the most common behavior regardless of conditions. A temperature range of 15–25°C with high humidity (70–90%) yielded the highest activity, with some species showing climate preferences. These results stress the need to consider weather when planning surveys.

**4. Observer Analysis:**

Elizabeth Oswald observed the highest number of birds (3248), species (98), and had the best initial detection rate (60%), showing strong field efficiency. Kimberly Serno followed closely. Brian Swimelar had the lowest metrics, emphasizing the importance of accounting for observer variability in ecological analyses.

**5. Temporal Analysis:**

Bird activity peaks in June and between 5–8 AM. This trend was consistent across May, June, and July. Species such as the Red-eyed Vireo and Acadian Flycatcher were most active in these windows. These insights support targeting early mornings in June for future surveys.

**6. Conservation Insights:**

Wood Thrush and Prairie Warbler are the most frequently observed among priority and watchlist species, signaling relative abundance. Kentucky Warbler’s low numbers suggest rarity or detectability issues. Most observed species (71.1%) are not under regional stewardship, prompting reevaluation of stewardship focus. Field Sparrow and Indigo Bunting, as regional stewardship species, are abundant, supporting their potential as habitat indicators.

**Grassland Data Analysis:**

**1. Species Frequency per Site:**

Among grassland sites, ANTI records the highest total bird count, with MONO leading in species diversity. HAFE consistently shows low bird abundance and richness. These results suggest MONO is key for biodiversity-focused efforts, while ANTI supports high overall bird populations.

**2. Species Behavior and Detection Patterns:**

Most birds were detected at 50–100 meters (5040), more than at ≤ 50 meters (3464), potentially due to habitat openness. Singing (4421) was the main detection type, followed by visual sightings (2700) and calling (1383). The majority of birds were detected within the first 5 minutes, especially between 0.25–2.5 minutes. Similar bird counts in Visit 1 (4317) and Visit 2 (4127) suggest survey consistency.

**3. Environmental Influence:**

Partly cloudy and clear skies and light air movement correlated with the most bird activity and species richness. Singing dominated under all conditions. The temperature-humidity scatter plot revealed species-specific environmental preferences. Mild, slightly dynamic weather optimizes observation opportunities.

**4. Observer Analysis:**

Elizabeth Oswald again had the highest metrics (3086 birds, 97 species, ~54% initial detection). Kimberly Serno had comparable totals (2990 birds), a slightly better initial detection (~55%), but fewer species (74). Brian Swimelar showed lower performance across all metrics. Observer skill greatly influenced data quality.

**5. Temporal Analysis:**

Observations peaked during 5–8 AM across all months. July saw spikes for certain species (e.g., Eastern Meadowlark), while May hosted the highest diversity (e.g., Field Sparrow, Carolina Chickadee). June had relatively lower activity. Timing significantly influenced detectability, supporting early-morning surveys in May and July.

**6. Conservation Insights:**

Wood Thrush and Prairie Warbler again dominate among conservation-priority birds. Kentucky Warbler's low counts point to possible vulnerability. Field Sparrow and Indigo Bunting lead among stewardship species, underscoring their value as indicators. Results mirror forest findings in prioritizing certain species and addressing low-detection taxa.

**Comparative Analysis - Forest vs. Grassland**

**1. Species Frequency and Site Analysis**

**Forest**

* **Prince William Forest Park (PRWI)** and **C&O Canal Historical Park (CHOH)** had the highest total bird counts.
* **CHOH** recorded the **highest species diversity**, designating it a biodiversity hotspot.
* **Wolf Trap National Park (WOTR)** showed the **lowest bird abundance and diversity**, possibly due to urban pressures or ecological limitations.
* PRWI, while abundant in birds, was dominated by fewer species, indicating lower evenness.

**Grassland**

* **ANTI (Antietam National Battlefield)** recorded the **highest bird abundance**, but not the greatest diversity.
* **MONO (Monocacy National Battlefield)** had the **highest species diversity**, suggesting habitat heterogeneity.
* **HAFE (Harpers Ferry National Historical Park)** performed poorly in both abundance and diversity.

**Comparison Insight**:  
Forest parks generally had **higher bird counts and species diversity overall**, although grasslands like MONO displayed comparable diversity. Forest habitats may support more consistent and structured ecological niches, while grasslands showed variability influenced by site conditions.

**2. Species Behavior and Detection Patterns**

**Forest**

* Most detections were **≤50m**, indicating closer-range detectability.
* **Singing** (5,426 detections) was the dominant behavior, followed by **calling** (2,675).
* Certain species like Wood Thrush and **Scarlet Tanager** showed delayed vocal activity.
* Visit 1 had slightly higher detections than Visit 2, indicating consistency.

**Grassland**

* More detections occurred at **50–100m**, likely due to open landscape.
* Singing remained the dominant detection method (4,421), but **visual detections** were significantly higher than in forests (2,700).
* Most birds were detected in the **first 5 minutes**, emphasizing the need for prompt survey starts.
* Similar observation counts between both visits confirmed sampling reliability.

**Comparison Insight**:  
Forests favor **close-range acoustic detections**, while grasslands allow for **longer-range and more visual detections** due to habitat openness. Singing is a dominant detection cue in both, though grasslands enable better visibility.

**3. Environmental Influence**

**Forest**

* Optimal bird activity occurred in **clear or partly cloudy skies** and **light winds** (<3 mph).
* Species richness dropped sharply in **foggy/misty** or **windy** conditions.
* Peak activity occurred at **moderate temperatures (15–25°C)** and **high humidity (70–90%).**

**Grassland**

* Bird activity peaked during **partly cloudy skies** and with **light air movement**.
* Singing and richness both increased in **mild weather.**
* Scatter plots showed **species-specific** environmental preferences.

**Comparison Insight**:  
Both habitats show similar responses to **favorable weather conditions**, with mild skies and light wind supporting better detectability. However, forest birds appear more sensitive to **humidity**, whereas grassland birds respond more to **air movement and sky clarity**.

**4. Observer Performance**

**Forest**

* **Elizabeth Oswald** had the highest overall performance: 3,248 observations, 98 species, and 60% initial detection rate.
* **Brian Swimelar** had the lowest across all metrics.

**Grassland**

* Elizabeth Oswald again led with 3,086 observations and 97 species.
* **Kimberly Serno** performed comparably in total detections but lagged in species richness.
* Brian had the lowest results here as well.

**Comparison Insight**:  
Observer trends were consistent across both habitats, affirming Elizabeth Oswald's superior performance and highlighting the importance of accounting for observer bias in ecological studies.

**5. Temporal Trends**

**Forest**

* **June** was the peak activity month.
* Bird observations were **concentrated between 5–8 AM.**
* Key species active in June included **Red-eyed Vireo, Ovenbird**, and **Acadian Flycatcher**.

**Grassland**

* **May** emerged as the most active month.
* Observations were again highest from **5–8 AM**.
* Grassland specialists like **Eastern Meadowlark**, **Field Sparrow**, and **Carolina Chickadee** dominated May.

**Comparison Insight**:  
Both habitats emphasize **early morning as optimal** for surveys, though **peak months differ** June in forests and May in grasslands. This likely reflects different phenologies and breeding cycles between forest and grassland birds.

**6. Conservation Insights**

**Forest**

* **Wood Thrush** and **Prairie Warbler** were the most observed among priority/PIF species.
* 71.1% of observed species were **not under regional stewardship**, suggesting a mismatch in priorities.

**Grassland**

* **Wood Thrush** and **Prairie Warbler** again topped priority lists.
* **Field Sparrow** and **Indigo Bunting** had **very high stewardship observations** (400+), indicating strong regional presence and monitoring potential.
* **Kentucky Warbler** was notably under-detected in both habitats.

**Comparison Insight**:  
Both ecosystems share key conservation targets like **Wood Thrush** and **Prairie Warbler**, but grasslands show stronger alignment with stewardship species (e.g., Field Sparrow). **Kentucky Warbler’s low detections** raise flags in both systems and warrant targeted conservation.

**Conclusion:**

The comparative analysis of forest and grassland ecosystems highlights distinct ecological patterns and important insights for bird monitoring and conservation. Forest habitats generally supported higher bird abundance and species diversity, reflecting their stable and structured environments, whereas grasslands exhibited more variability influenced by site-specific conditions. Detection patterns differed, with forests favoring close-range acoustic detections and grasslands allowing for longer-range visual observations due to their open landscapes. Environmental factors such as temperature, humidity, wind, and sky conditions significantly influenced bird activity, with forests showing greater sensitivity to humidity and grasslands responding more to visibility and air movement. Observer performance remained consistent across both ecosystems, emphasizing the importance of accounting for observer bias. Temporally, bird activity peaked in June for forests and May for grasslands, aligning with their respective breeding cycles. Conservation insights revealed shared priority species such as the Wood Thrush and Prairie Warbler, while grasslands also supported a higher proportion of regional stewardship species like the Field Sparrow. However, the notably low detection of the Kentucky Warbler in both ecosystems signals a need for targeted conservation efforts. Overall, the study underscores the necessity of habitat-specific strategies and a nuanced understanding of ecological, behavioral, and environmental variables to inform effective biodiversity monitoring and management.

**Actionable insight:**  
 The analysis reveals that bird monitoring efforts should be tailored to habitat-specific dynamics—acoustic detections work best in forests due to closer-range bird activity, while visual detections are more effective in open grasslands. Conservation resources should prioritize biodiversity hotspots like CHOH and MONO, while underperforming sites such as WOTR and HAFE warrant habitat restoration or disturbance mitigation. Surveys are most effective in the early morning (5–8 AM), especially during peak months June for forests and May for grasslands. Observer training is crucial, as performance varies significantly; leveraging top observers can improve consistency. Environmental factors like sky clarity and wind should guide fieldwork timing to enhance species detection, with forest birds particularly sensitive to humidity. Importantly, grasslands show stronger alignment with stewardship species, suggesting a need to balance efforts across habitats. Under-detected species like the Kentucky Warbler require focused monitoring. These insights support adaptive, data-driven management to improve biodiversity outcomes and ecological stewardship.