Comparison of Reclaimed and Unmined Woodcock Summer Diurnal Habitat in West Virginia

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Abstract: Reclaimed surface mines are used by American woodcock *(Scolopax minor)* as diurnal habitat during summer in West Virginia. However, habitat quality of these sites relative to that of other (unmined) diurnal habitat in West Virginia has not been previously evaluated, making it difficult to assess the potential for using mine reclamation to create woodcock habitat. We compared vegetation and soil characteristics at points where we flushed woodcock on reclaimed surface mines (25 flush points at 11 sites) and unmined locations (26 flush points at 13 sites) in West Virginia during the summers of 1995–1997. We provide baseline information on soil characteristics of unmined summer diurnal habitat in this part of the woodcock's range and assess relative quality of reclaimed summer diurnal habitat. Quality of overhead cover was similar at reclaimed and unmined areas, but unmined sites provided more lateral cover because of greater stem densities ($\bar{x}$ = 16,715/ha, SE = 3,550 vs. $\bar{x}$ = 4,249/ha, SE = 745, P = <0.001). Soils in unmined habitats had greater moisture retention capabilities and organic matter content, but soil pH was low in both reclaimed and unmined areas and could depress earthworm availability in both types of habitat. Existing reclaimed habitat is of similar quality to unmined habitat in some respects but also has some deficiencies; thus, managers should continue to focus on maintaining high quality unmined habitats, but also seek to take advantage of the potential of mined areas as woodcock habitat through reclamation efforts specifically targeted to this species.

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American woodcock populations, as indexed by the annual Singing-ground Survey, have declined over the past 30 years (Kelley 2000). These declines generally are attributed to losses of early successional habitat caused by forest succession and

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human activities (Dwyer et al. 1983, Straw et al. 1994). In West Virginia, an increase in the amount of deciduous forest was associated with decreases in woodcock numbers along Singing-ground Survey routes (Steketee et al. 2000). As one means of reversing these trends, creating new habitat was identified as a research and management priority in the American Woodcock Management Plan (U.S. Fish and Wildl. Serv. 1990).

To determine if surface mine reclamation might be a current or potential means of creating new summer diurnal habitat for woodcock, Gregg (1997) conducted flush surveys for woodcock using pointing dogs on 29 surface mines in West Virginia of various ages and reclamation types. Diurnal use by woodcock occurred on 11 of these sites.

Although woodcock were using reclaimed mines, diurnal habitat used had low stem densities and earthworm biomass (Gregg 1997) relative to high quality habitat reported in other studies. Most of these studies, however, were conducted in other areas of woodcock range, raising the possibility that differences were influenced by geography as well as land-use history.

Little previous information on vegetation characteristics of unmined diurnal habitat in West Virginia was available for comparison, but as part of a companion study using remote sensing to inventory woodcock habitat in the state, Steketee (2000) conducted similar flush counts and vegetation measurements in unmined woodcock diurnal habitat, providing an opportunity to make such comparisons. In our study, we collected soil data from unmined sites near the reclaimed study sites and quantitatively compared vegetation and soil conditions at unmined and reclaimed diurnal habitat used by woodcock in West Virginia. Our objectives were to provide baseline information on soil characteristics of unmined diurnal habitat in West Virginia and to better assess relative quality of woodcock habitat on reclaimed surface mines.

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Methods

Reclaimed diurnal habitat was assessed at 25 points on 11 reclaimed mine sites where Gregg (1997) located woodcock during August 1995, June 1996, and August 1996. Reclaimed sites were located in Monongalia (1 flush point), Tucker (6 points on 4 sites), Randolph (5 points on 2 sites), and Greenbrier (13 points on 4 sites) counties, West Virginia. No woodcock were detected on 18 additional sites (Gregg 1997).

Habitat characteristics of mined sites varied depending on regulations in effect at the time of mining (Gregg et al. 2000). Four sites (8 flush points) >25 years old received little reclamation because of minimal legal requirements. Because they had not been recontoured, these sites included relatively flat bench areas from which coal had been removed with vertical highwalls upslope and slightly elevated spoil banks down-slope. Plant species on benches and spoil banks included red maple *(Acer rubrum),* black birch *(Betula lenta),* black cherry *(Prunus serotina),* bigtooth aspen *(Populus grandidentata),* and blackberry *(Rubus* spp.), and were representative of surrounding vegetation. Three sites 10–18 years old, with 4 flush points, (reclaimed under provisions of the federal Surface Mining Control and Reclamation Act) were recontoured with replaced topsoil. Planted woody species included black locust *(Robinia pseudoacacia),* autumn olive *(Eleagnus umbellata),* black alder *(Alnus glutinosa),* and pines *(Pinus* spp.). Three sites 18–25 years old, with 7 flush points, (reclaimed under 1971 state standards) exhibited topography, soil, and vegetation characteristics intermediate between these extremes. Finally, 1 additional site with mixed-age reclamation had 5 flush points in >25-year-old sections and 1 flush point in a 10- to 18-year-old section. Habitat characteristics of specific reclaimed surface mine study areas were described in more detail by Gregg (1997).

Steketee (2000) surveyed unmined woodcock habitat using pointing dogs in June–August 1995–1997. To compare to reclaimed diurnal habitat, we selected 13 of these sites, including 26 flush points, representative of the most common types of unmined diurnal habitat in the state. To minimize spatial variability, we selected sites located near reclaimed sites, generally within the same counties. Locations included 2 points on one site in Monongalia County, 10 points at 6 sites in Tucker County, 2 points at 1 site in Grant County, 6 points at 3 sites in Randolph County, and 6 points at 2 sites in Greenbrier County.

Two unmined sites (2 flush points) consisted of 10- to 20-year-old northern hardwood regeneration. Five sites (10 flush points) were reverting fields with early successional species such as hawthorn *(Crataegus* spp.), cherry *(Prunus* spp.), and bigtooth aspen. Five sites (11 flush points) were shrub wetland / lowland areas with alder *(Alnus* spp.), willow *(Salix* spp.), spruce *(Picea* spp.), and spirea *(Spirea* spp.), and 1 additional site had 2 flush points in reverting field habitat and 1 in a shrub wetland area.

At each flush point, we measured vegetation and soil variables related to woodcock cover and food. Vegetation (cover-related) variables included size class of overstory, percentage canopy at 0–1 m, 1–3 m, 3–6 m, and 6–9 m, and number of woody stems/ha. We measured vegetation at all flush points using 0.04-ha circular plots with

11.3-m transects in each cardinal direction from the center point (James and Shugart 1970). Vegetation data were collected during August 1995 and June–August 1996 on reclaimed sites, and June through August 1995–1997 on unmined sites. Due to personnel constraints, it was not possible to collect all vegetation data at the same time woodcock were flushed; however, all vegetation data were collected within 2 months of the time a woodcock was flushed at a given point. Because all woodcock were flushed after full leaf-out, the size class, canopy cover, and stem density variables we measured were representative of vegetation conditions at the time of woodcock use despite delays in sampling. We measured percentage cover variables by recording presence or absence of vegetation with a sighting tube at 21 sampling points within the plot (plot center point plus 5 points at equal intervals along each 11.3-m transect). We determined stem density from number of all shrub and tree stems intercepted by a 1-m band at breast height along each transect. We determined overstory size class by measuring diameter at breast height (DBH) of up to 5 overstory stems within 5 m of the center of the plot and classifying by average DBH as:

1. class 1 = no overstory
2. class 2 = saplings (<15 cm DBH), <25% woody cover
3. class 3 = saplings (<15 cm DBH), >25% woody cover
4. class 4 = pole timber (15–25 cm DBH).

We collected soil samples from reclaimed points concurrently with vegetation measurements in August 1995 and June–August 1996, and from all unmined points during July and August 1997. Because samples at unmined sites were not all collected at the same time as those at reclaimed sites, or close to the time of woodcock use, variables exhibiting large temporal variability (e.g., percentage moisture content, earthworm biomass) would not have provided valid comparisons. Instead, we measured 4 variables that remain relatively constant between different seasons/years and that related to value of the soil in providing woodcock food: pH, organic matter content, compaction, and water retention difference (WRD; Soil Survey Staff 1984). WRD measures capacity of the soil to retain moisture; the higher a soil's WRD, the more of a given amount of water it will retain in terms of both length of time and amount. Because it is independent of percentage moisture content at any one time, WRD is a better measure of long-term availability of water to plants and earthworms in soil than is percentage moisture content (Gerard 1967).

We collected soil samples by using a trowel and a 2-cm diameter corer, then air-dried samples and sieved them to remove fragments >2mm. We determined soil pH with a Fisher Accumet 915 pH meter on a 1:1 soil:water paste (Sobek et al. 1978). We determined percentage organic matter from loss-on-ignition at 550 C (Blume et al.1990). We determined WRD by calculating the difference in percentage moisture retained between a pressure plate at 33 kPa and a pressure membrane at1500 kPa (Soil Survey Staff 1984). Also, we assigned a compaction rating in the field based on amount of effort required to penetrate the soil with a 0.6-cm diameter tent stake, with 1 being least compacted (almost effortless penetration) and 5 being most compacted (near-impossible to penetrate). Because soil moisture content could affect ease of

Table 1. Vegetation and soil characteristics at reclaimed and unmined American woodcock flush points in West Virginia, 1995–1997. Sample sizes = 25 for reclaimed points and 26 for unmined points.

	Reclaimed points			Unmined points				
Variable	$\bar{x}$	(SE)	Range	$\bar{x}$	(SE)	Range	Z^e	P^e
Overstory size class[a]	3.5	(0.1)	3-4	2.9	(0.1)	2-4	3.77	<0.001
0–1 m % canopy	76.4	(3.7)	38-100	81.3	(2.7)	50-100	0.73	0.468
1–3 m % canopy[b]	53.5	(3.1)	29-81	43.9	(4.0)	5-76	1.48	0.138
3–6 m % canopy	55.8	(5.3)	5-100	42.5	(5.0)	0-81	1.76	0.079
6–9 m % canopy[b]	39.8	(7.1)	0-100	18.8	(4.8)	0-95	2.16	0.031
N woody stems/ha[b]	4,249	(745)	678-19,888	16,715	(3,550)	2,712-74,806	-3.90	<0.001
WRD (cm water/cm soil)[bc]	0.14	(0.01)	0.001-0.28	0.34	(0.02)	0.18-0.48	-5.77	<0.001
Soil pH[b]	4.73	(0.09)	3.74-5.44	4.48	(0.12)	3.75-6.15	1.78	0.075
Soil organic matter %[b]	15.5	(1.6)	7.9-43.2	21.2	(1.5)	6.7-35.6	0.002	0.002
Soil compaction[d]	2.8	(0.2)	1-4	2.5	(0.3)	1-5	0.283	0.283

a. Overstory size class categories: 1 = no overstory, 2 = saplings (<15 cm DBH), <25% woody cover, 3 = saplings (<15 cm DBH), >25% woody cover, 4 = pole timber (15–25 cm DBH).

b. Entered in stepwise logistic regression.

c. Included in final logistic regression model.

d. Soil compaction rated as 1–5 with 1 being least compacted (almost effortless penetration with probe) and 5 most compacted (near impossible to penetrate).

e. Wilcoxon rank-sum test, normal approximation.

penetration, we avoided taking compaction measurements during periods of extremes in soil moisture.

Because sample sizes from individual years and habitat subtypes were small, and because incorporating the range of variability within both reclaimed and unmined habitat better enabled us to meet our objective of making a broad comparison of the 2 types, we grouped all reclaimed and unmined points for analysis. We first used Wilcoxon rank-sum tests (SAS 1995) to compare each individual habitat variable for reclaimed and unmined flush points. Variables were considered significantly different at $\alpha \leq 0.05$. Variables with α between 0.05 and 0.25 also were considered potentially useful predictors and retained for further analyses. We next examined Spearman rank-order correlations between all variables with $\alpha \leq 0.25$ to identify any highly correlated pairs ($|r_s| > 0.40$, $P < 0.001$) and, for any such pairs, eliminated the variable with the greater Wilcoxon α value. Finally, we entered the remaining noncorrelated variables in stepwise logistic regression models to identify the most effective variables for differentiating mined and unmined points. Significance levels for adding or removing variables were set at $\alpha = 0.05$.

Results

Flush sites on reclaimed areas had approximately 75% fewer woody stems/ha, a larger overstory size class, and greater percentages of canopy cover above 6 m compared to unmined sites (Table 1). Soils at reclaimed flush points had lower organic matter and WRD values than unmined sites (Table 1).

We initially considered 8 variables with $P \leq 0.25$ (Table 1) for inclusion in stepwise logistic regression. We ultimately included 1–3 m percentage canopy, 6–9 m percentage canopy, number of stems/ha, WRD, pH, and organic matter. We eliminated overstory size class and 3–6 m percentage canopy from analyses because of strong correlations with 6–9 m percentage canopy ($r_s = 0.59$, $P < 0.001$ for overstory size class, and $r_s = 0.61$, $P < 0.001$ for 3–6 m percentage canopy). Stepwise logistic regression identified a single variable, WRD, as the most useful for differentiating reclaimed and unmined points. The resulting model ($c^2 = 48.67$, $P < 0.001$, $R^2 = 0.69$) was:

$$\text{Point type (reclaimed or unmined)} = 8.274 - 36.006 \cdot \text{WRD}.$$

Discussion

Interpreting differences between woodcock summer diurnal habitat on reclaimed and unmined areas is complicated by the considerable variability in habitat characteristics of woodcock use sites in both habitat types (Table 1). This variability suggests that the suitability of different habitats may vary as weather conditions and habitat availability change. However, certain vegetation and soil features were characteristic of the 2 types of habitat we examined. The similarities and differences between such features on reclaimed and unmined sites provide insight into relative habitat quality of each habitat type, and associated management implications.

Vegetation Characteristics

If both reclaimed and unmined sites were following a typical successional progression, lower stem densities, larger overstory size class, and greater percentage of canopy cover above 3 m on reclaimed points might suggest that points on mined sites were older and had passed the stem exclusion period (Smith 1986). However, the magnitude of soil and seed bank disturbance in mining precludes most reclaimed sites from following a typical successional pathway (Gregg 1997). Thus, the primary reason that reclaimed mines have low stem densities is that fewer stems become initially established due to the extent of disturbance.

Stem densities at our unmined sites in West Virginia were lower than those reported for Minnesota (Morgenweck 1977) and Pennsylvania (Hudgins et al. 1985), but similar to those reported by Rabe (1977) in Michigan. Cover quality for woodcock is reduced when stem densities are lower (Straw et al. 1986) and the additional lateral cover provided by more stems is important during periods of leaf-off, such as initiation of nesting (McAuley et al. 1996) and migration. Quality of lateral cover at unmined sites in West Virginia seems comparable to that in some other parts of the range. However, reclaimed sites provide lower-quality lateral cover because of lower stem densities.

Although canopy cover above 6 m differed between reclaimed and unmined sites, the range of suitable canopy closure values for shrubs and trees seems fairly broad (Wishart and Bider 1976, Straw et al. 1986). Thus, diurnal habitat on both unmined and reclaimed sites in West Virginia appeared to provide suitable overhead cover (neither too sparse nor too dense) in both the shrub and overstory layers.

Soil Characteristics

Lower WRD values of reclaimed sites likely reflect a combination of factors, including greater proportions of rock fragments and lower organic matter (Johnson and Skousen 1995). Our results confirmed that levels of soil organic matter are greater at unmined sites. In addition to increasing retention of soil moisture, higher levels of organic matter provide more food for earthworms (Lee 1985). Other conditions being equal, greater moisture retention and organic matter content might be expected to translate into more earthworms (and thus greater habitat value for woodcock) at unmined habitats.

However, soil pH, which also influences earthworm abundance, was low at both unmined and reclaimed sites. Numerous studies have noted lower earthworm populations in soils in the pH 4–5 range (typical of most of our sample points, both reclaimed and unmined) than at higher pH ranges (e.g., Reynolds 1977, Lee 1985, Owen and Galbraith 1989). Therefore, it is possible that despite better water retention and organic matter conditions at unmined sites, low soil pH might depress earthworm abundance in both reclaimed and unmined habitats in West Virginia. Earthworm biomass on both reclaimed and unmined sites (1.6 g/m^2 and 2.5 g/m^2, respectively; I.D. Gregg and P.B. Wood, unpubl. data) was below the 8 g/m^2 reported as suitable for woodcock by Parris (1986) and values reported by Morgenweck

(1977), Reynolds et al. (1977), and Sepik and Derleth (1993) in other parts of woodcock breeding range.

Management Implications

The fact that woodcock are using reclaimed mines in West Virginia suggests that mines may be the best available habitat in some areas, although this habitat may not be optimal for woodcock (Sepik et al. 1989). Some soil conditions in reclaimed diurnal habitat and low stem densities relative to unmined diurnal habitat are of concern. Thus, we believe that the first priority for managers in regard to summer diurnal woodcock habitat in this part of the range should be to identify and maintain the highest quality unmined habitats, and that it would be inadvisable to view mine reclamation as a means of managing existing high-quality habitat.

However, woodcock also may benefit if mine reclamation is used to create summer diurnal habitat in areas where it does not currently exist. Despite the fact that previous reclamation efforts have not been specifically targeted to woodcock, they are already using existing reclamation, and overhead cover and soil pH are similar at reclaimed and unmined diurnal habitat sites. Thus, there should be good potential for future reclamation and management of surface-mined areas to improve upon the shortcomings we have identified in existing reclaimed woodcock habitat.

We suggest that managers interested in creating summer diurnal habitat through mine reclamation focus on recently reclaimed sites. Overall soil conditions are better in recent reclamation; earthworm biomass in reclamation <5 years old is closer to levels reported for diurnal habitat in other parts of the range (Gregg 1997). Such sites currently do not provide adequate cover for diurnal habitat, partly because woody plantings have been de-emphasized in recent reclamation and, even when present, woody cover has not had sufficient time to develop structure suitable for woodcock. An emphasis on development of woody cover on these sites would greatly enhance their quality as woodcock habitat and should be easier to accomplish than improving soil conditions on older reclaimed sites.

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