Wildlife response to strip-mine reclamation in southwest Virginia
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Introduction

Post-mined lands can be managed for a number of different land uses including managed pasture for grazing livestock, commercial forest products, outdoor recreation, and carbon sequestration. Regardless of the post-mining land use, there will always be opportunity to manage the land to provide suitable wildlife habitat. For example, several studies suggested that the new environments created by strip mining are beneficial to wildlife not common to the area or that are suppressed by limited resources and competition (Allaire 1978, Whitmore and Hall 1978, Rohrbaugh and Yahner 1996 Bajema et al. 2001). Much of the area affected by coal mining in Virginia is forested ridgetops which provide important nesting habitat for species of concern such as the cerulean warbler (*Dendroica cerulea)*; however, reclaiming strip mines creates large amounts of early successional habitat used by many other species that are currently in decline such as the field sparrow (*Spizella pusilla)*, golden-winged warbler (*Vermivora chrysoptera)*, and yellow-breasted chat (*Icteria virens)* (Carrozzino 2009). Therefore, reclaimed strip-mines provide a unique opportunity to study habitat use by birds and identify critical components of the habitat that are important for management.

Loss of breeding habitat due to fragmentation has been hypothesized as a major cause of population declines in forest-nesting Neotropical migrant birds (Donovan and Flather 2002). Surface mining activities can also lower the structural diversity of various cover types and may lead to structural and compositional changes in avian communities (Wray et al. 1982). Changes in cover types could also cause a change in the predator community and thereby alter predator-prey dynamics. Sedimentation from erosion can impact aquatic habitats and the various vertebrate and invertebrate communities associated with them. Other environmental issues that may impact wildlife populations on surface mines include noise, air quality, construction and use of temporary road systems, and environmental contamination.

Many studies have focused on the negative impacts of surface mining activities on wildlife; however, few studies have assessed the potential value of post-mined lands as wildlife habitat and provide management recommendations for the development of suitable habitat for wildlife (Carrozzino 2009). Carrozzino (2009) found a predictable trend between breeding bird species richness, and abundance and successional stage on reclaimed surface mines. While her study confirmed suitability of reclaimed mine-lands for some wildlife, species richness and abundance may not be reliable measures of habitat quality in all cases (VanHorne 1983). An understanding of nest-site selection and nesting success is important to understanding the ecology and evolution of species and to develop management recommendations (Rodewald 2004). Such knowledge will contribute to our understanding of the contribution of reclaimed mine lands to sustaining populations of bird species of concern.

The primary focus of this study was to determine breeding success of birds nesting on reclaimed mine sites, specifically focusing on sites reclaimed using the Forest Reclamation Approach (FRA)(Burger et al. 2005). The continued monitoring of avian populations contributes to the data collected by Carrozzino (2009) in order to evaluate changes in avian community structure over a 5-year period as the reclaimed sties mature. In 2010, we collected data on the use of reclaimed mine sites by medium and large sized mammals but did not continue monitoring in 2011 because of issues of vandalism encountered in 2010. We did not expect a significant change in the mammalian community over a 1 year period.

Research Objectives

This research is intended to contribute to our understanding of wildlife use of reclaimed mine lands. The specific objectives are:

1) Assess breeding bird community composition in various cover types reclaimed for different post-mining land uses on Powell River Project.
2) Monitor breeding success of songbirds (with emphasis on species of concern in Virginia) in varying mine reclamation regimens specifically focusing on sites reclaimed to hardwoods and are FRA compliant.
3) Determine what environmental factors may influence breeding success of songbirds in different cover types.
4) Model finite rate of increase of common songbird populations on the Powell River Project, using survival estimates from other studies in the region and our estimates of nest success to determine to what extent reclaimed mine lands contribute to populations.
5) Assess mammal community focusing on potential avian nest predators at The Powell River Project to determine its use of reclaimed mine sites and relate distribution and abundance to habitat conditions.
6) Relate information gained in this study to previous information about wildlife management on reclaimed mine sites to make recommendations about reclaiming lands for wildlife use.

This phase of the study has been completed and reported in a thesis by Chris Latimer (Latimer 2012). We here provide an overview of the approach and most important results from the work. Two manuscripts are currently prepared to submit for publication.

Overview of Methods

Field work was conducted at the Powell River Project site in Wise County, Virginia, and surrounding reclaimed surface mines in Appalachia, Dickenson and Russell Counties. Sites for this study were chosen from patches of relatively homogeneous vegetation cover of similar age, reclaimed under the same technique (pre-SMCRA, FRA, grassland/pasture). Because of the relatively recent development and application of the Forest Reclamation Approach, availability of FRA sites is limited and most FRA sites are <20 years old. Therefore, in an effort to increase sample size, we also sampled sites that were FRA compliant. Because the maximum age of existing FRA site is <20 years of age, we only considered sites that had been reclaimed or undergone natural succession within the past 20 years. Because we are evaluating differences in patches reclaimed using different techniques, pre-SMCRA sites (no active reclamation) were sampled to collect baseline data. We located as many patches as possible on the 2 study areas that were large enough (3-4ha) for sampling and met the above constraints. Some patches were large enough to contain multiple sampling points; therefore, the number of sampling points was appropriate to the size of the patch sampled such that each point was >200m apart (Table 1).

Table 1. Number of points and location of study sites in Wise and Dickinson Counties, VA. For the 2010 and 2011 field seasons.

	# of points		
Site	2010	2011	Location
Powell River	32	36	Wise
PALS	7	34	Dickenson
Mud-Lick Creek	4		Above Appalachia
TNC Flint Gap	4	4	Russell

† Mud-Lick Creek sites were not sampled in 2011 because they were inaccessible by vehicle.

Bird Sampling

Survey points in pre-SMCRA, pasture and traditional reclamation cover types were adopted from Carrozzino (2009) and additional points were located within FRA and FRA-compliant cover types. We used variable radius point counts to record bird species and distance from point center to each individual bird. Laser rangefinders were used in 2011 to help aide in distance estimation. Sex and age class (if known) were also recorded for each individual. Each point was visited 4 times between May 18 and Aug 9 in 2010 and 5 times between May 10 and June 24 in 2011. All counts lasted a total of 5 minutes with a 1-minute "settling period" after arriving at each point. All surveys were conducted between 6 and 10 am on clear mornings with minimal wind. Observers and time of day were alternated between counts to minimize any biases that may occur. In 2011, observers used a rangefinder to aide in distance estimation.

Nests were located from late April to mid-July by using behavioral cues and systematically searching potential nesting substrates. A total of 58 nests from 18 different species was located in various cover types in 2010. In 2011, we focused our search efforts on field sparrows and indigo buntings to help increase our sample size. We found 54 nests of 6 species in 2011, bringing the overall total number of nests across the 2 year sample to 112 nests of 19 species. (Table 2, Figure 1). Nests were checked every 2 to 3 days to monitor the contents and status of the nest. Steps were taken to minimize disturbance around the nest and to avoid potentially leading predators to the nest. A pole with a mirror was used to check the contents of nests located higher in the canopy as well as in the shrub layer to minimize disturbance.

Habitat measurements were taken within 10 days of the successful completion (at least one young fledging) or failure of a nest. Measurements were taken at 2 different spatial scales at used and unused nest sites. Unused sites were determined by choosing a random compass bearing and pacing at least 30m to the nearest nesting substrate of the same plant species as the used nest-site. At the area surrounding the nest within a 1m radius, we measured the following habitat characteristics: nest height (m), nest substrate (spp. and DBH if applicable), distance from center of nest to center of substrate, distance from the center of the nest to the edge of the substrate, and distance of nest to nearest edge (the junction between two different cover types, or the same cover type with visible differences in age). Each edge was scored on a scale from 1 to 5, with 1 representing little contrast between 2 patches (same cover type, different age) and 5 representing the greatest contrast (e.g., junction between forest and pasture). Percent concealment of the nest was measured by visually estimating the percentage of the nest that was constructed by vegetation from 1m in each cardinal direction, above and below and then averaged to obtain an estimate of the total concealment.

Table 2. Number of nests by species located on reclaimed mine lands in Wise and Dickinson Counties in 2010 and 2011.

	# Nests	
Common name	**2010**	**2011**
Black-and-white warbler	2	0
Blue-gray gnatcatcher	1	0
Blue jay	2	0
Brown thrasher	2	0
Cedar waxwing	1	0
Chipping sparrow	1	0
Common yellowthroat	0	1
Field sparrow	17	34
Gray catbird	2	0
Golden-winged warbler	1	0
Hooded warbler	1	0
Indigo bunting	15	15
Northern cardinal	1	0
Prairie warbler	3	1
Red-eyed vireo	2	0
Red-winged blackbird	1	0
Grasshopper sparrow	2	0
White-eyed vireo	2	0
Wild turkey	1	1
Yellow-breasted chat	1	3
Totals	58	55

Habitat measurements were also taken at the patch scale, defined as the area encompassed by a 0.04ha circular plot centered on the nest. At this scale, we measured percent canopy cover, canopy height, density of trees > 10 cm diameter at breast height (DBH), density of stems > 4 and < 10cm DBH (saplings/poles), and density of stems < 4cm DBH (shrubs). An estimate of understory foliage volume was obtained by using a standard vegetation profile board (Nudds 1977) divided into 5 height intervals, 0-0.5m, 0.5-1m, 1-1.5m, 1.5-2m and 2-2.5m. The board was 2.5m tall and 30.48cm wide with alternate black and white colors at 0.5m intervals. The proportion of each 0.5m interval covered by vegetation was be recorded on a scale from 1 to 6, corresponding to the 6 cover classes presented in Daubenmire (1959). Readings were taken 10m in each cardinal direction from the nest at a height of 1m and the average for each 0.5m interval will be used in analyses. Percent ground cover by category (grasses, forbs, woody vegetation <1m, moss, leaf litter), percent bare ground, rocks, and percent coarse woody debris (CWD, woody vegetation > 8cm DBH and >1m long) were also taken by using the point intercept method.

We modeled nest success for indigo buntings and field sparrows using the nest survival model platform in program MARK (White and Burnham 1999). We evaluated the effects of various factors such as year, site, climate, and vegetation on nesting success for these two species.

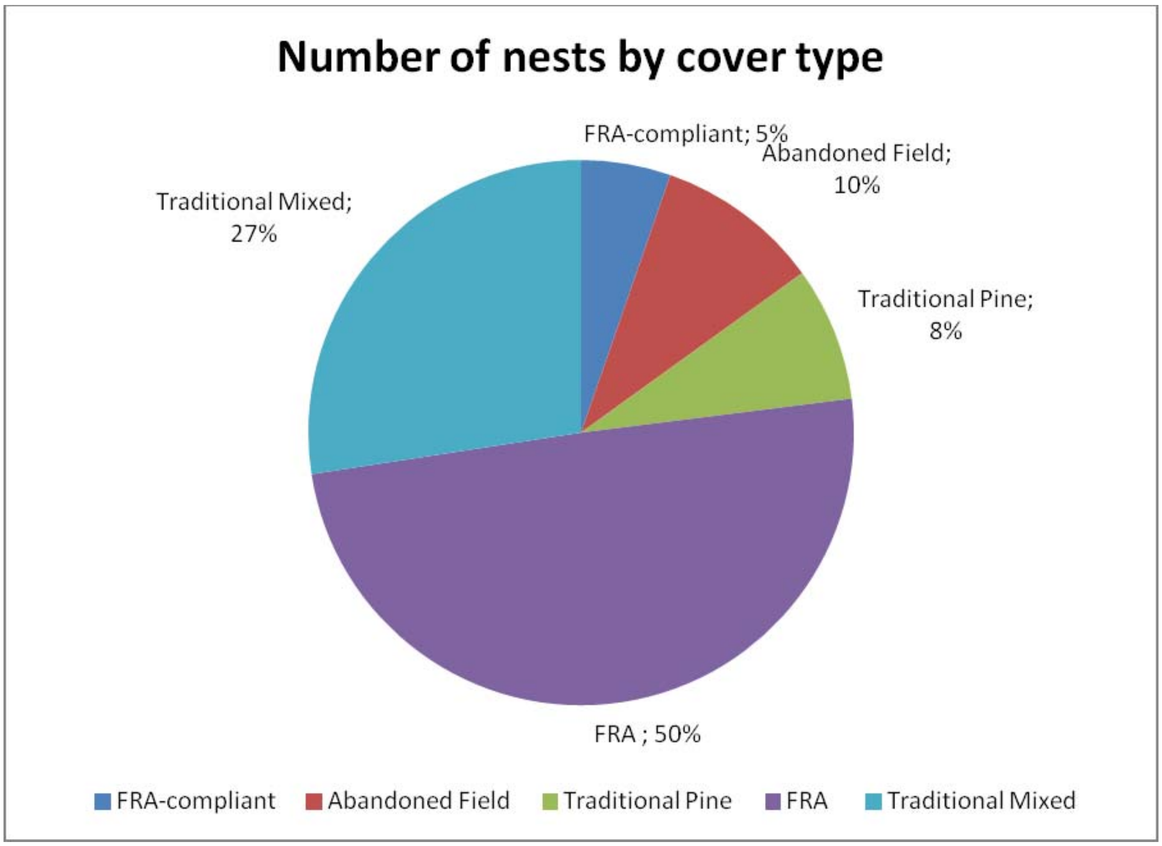

Figure 1. Number of nests located in cover types sampled in Wise and Dickinson Counties, VA, 2010 and 2011.

Mammal sampling

Remote sensing camera-traps were used to inventory mid- to large-sized mammals in different cover types at the Powell River site in 2010. Cameras were spaced approximately 1km apart in areas of suspected animal activity (based on scat, trails, and tracks). A total of 9 camera-traps was deployed from June 5 through July 13, totaling 38 trap-nights per camera for a total of 342 trap-nights for the entire study area. Camera-traps were taken down early as a result of theft on the Powell River Project. Animal activity was calculated as the number of independent capture events for a single species divided by the total number of trap nights, and relative animal activity was calculated as the number of independent capture events for a single cover type divided by total capture across all cover types (Figure 3, Table 2). Consecutive photos of the same species were considered independent events if individual animals can be unambiguously identified, or if the interval between capture events was >30 minutes (Michalski and Peres 2007).

Table 3. Relative animal activity by cover type. Numbers expressed as # animals/# trap nights.

Relative Animal Activity								
	Black Bear	Bobcat	Coyote	Gray Squirrel	Raccoon	White Tailed Deer	Wild Turkey	Other
FRA	0.20	0.00	0.20	0.00	1.00	0.13	0.40	0.50
Early	0.40	0.50	0.60	1.00	0.00	0.71	0.35	0.10
Mid	0.13	0.00	0.00	0.00	0.00	0.08	0.00	0.20
Ref	0.13	0.25	0.20	0.00	0.00	0.08	0.17	0.00
PreSMCRA	0.13	0.25	0.00	0.00	0.00	0.00	0.08	0.20

*Trap nights = 342

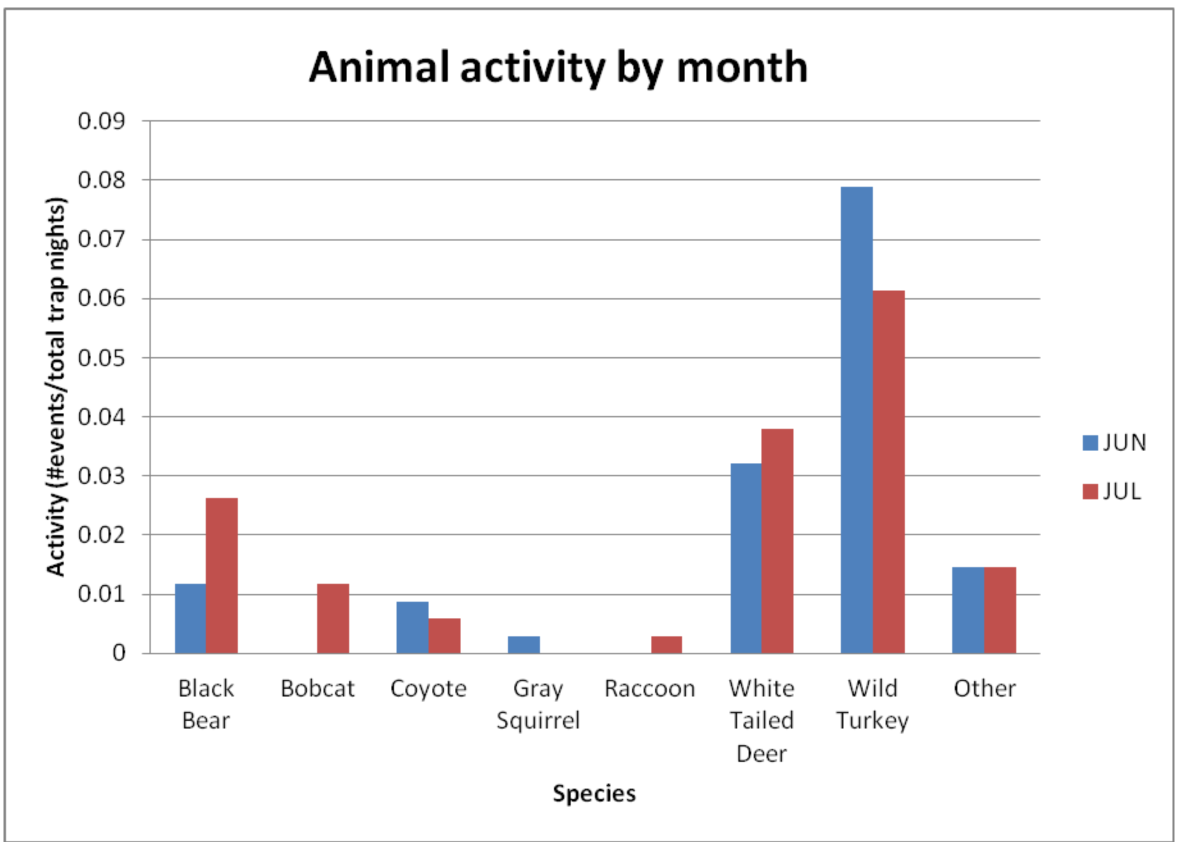

Figure 2. Animal activity by month expressed as # of independent capture events/ trap nights per station. Avian Nesting Success

During the study we found nests of 20 bird species; the majority of nests found were for field sparrows and indigo buntings (Table 2). We intensively analyzed nesting success for these two species. We found a total of 51 field sparrow nests and 30 indigo bunting nests for the 2010 and 2011 breeding seasons combined. Of these 81 nests, 43 (53%) failed. Of the 43 nests that failed, 3 (6%) were abandoned, 35 (81%) were depredated, 3(6%) were lost due to poor nest placement (woven between 2 substrates that grew at different rates and caused the nest to tip), and 2 (5%) failed due to unknown causes. Only one indigo bunting nest was parasitized by a cowbird, but was depredated before the eggs hatched. Brown-headed cowbirds are typically associated with highly disturbed habitats and cattle operations, and can severely impact nesting success. It appears that the reclaimed mine lands studied here are remote enough from potentially colonizing populations and had few enough cattle that any potential negative effect of cowbirds was minimal.

While we allocated search effort evenly among the various reclamation cover types, we only found nests of field sparrows and indigo buntings in pasture, traditional shrub, and forest reclamation cover types, suggesting the other cover types may not provide adequate nesting habitat for either of these species. The daily survival rates for each species did not vary among these three cover types (Figure 3).

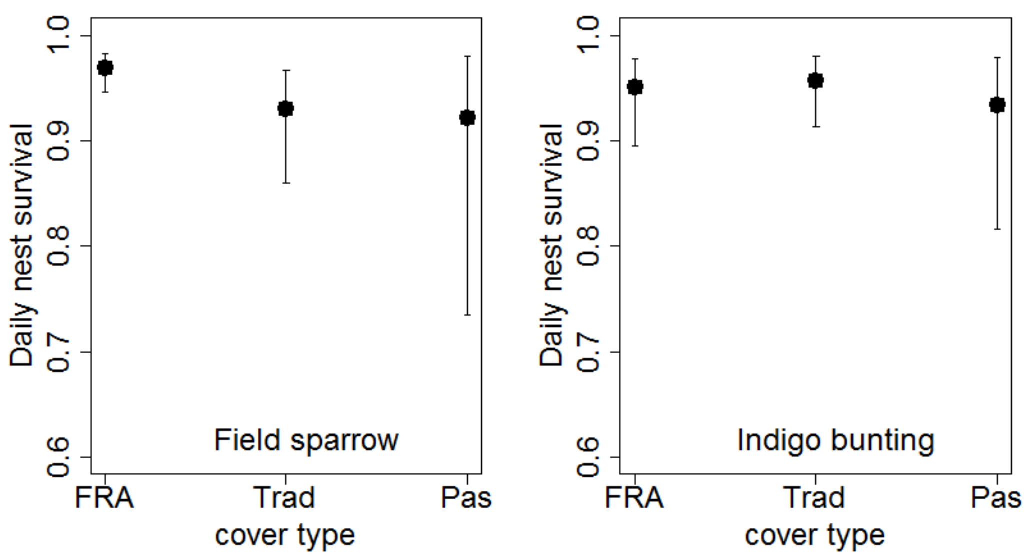

Figure 3. Effect of reclamation type on daily nest survival for field sparrows and indigo buntings. Values represent the combined success over 2010 and 2011.

Nesting success in field sparrows increased with vegetative concealment at the nest site; however there was a negative relationship to the cover of woody vegetation within 11 meters of the nest, indicating that a dense nesting substrate with relatively open surrounding area is best for field sparrows. There were no strong relationships between the habitat variables sampled and nesting success for indigo buntings; however, for early indigo bunting nests, woody cover 0.5 – 1.5 m above the ground was higher at successful nests.

We estimated seasonal fecundity to be 1.04 female offspring/adult female for indigo buntings when daily nest survival rates were averaged across 2010 and 2011. When separated by year, seasonal fecundity was 1.61 and 0.61 female offspring/adult female for 2010 and 2011 respectively. Field sparrows had a higher seasonal fecundity estimate of 1.83 female offspring/adult female. There was no yearly difference found in field sparrow fecundity.

We evaluated simple population models incorporating our observed nesting success, and a range of adult and juvenile survival rates. For indigo buntings, the populations would be potentially self-sustaining for an adult annual survival rate of 80% and a juvenile survival of 30%. For field sparrows, when adult annual survival is at least 80%, a minimum juvenile survival rate of 25% would result in a self-sustaining population. These represent "what if" scenarios, as we do not have available data on juvenile and adult survival in this region for indigo buntings and field sparrows. However, we feel that the values used are reasonable.

Implications for mine reclamation

The combined results of Carrozzino's (2009) and Latimer's (2012) studies have provided useful information regarding the value of reclaimed lands to songbirds in southwestern Virginia. The dominant findings include:

- A great diversity of birds find reclaimed mine-lands suitable habitat. We recorded over 80 avian species using reclaimed lands.
- Bird species dependent on mature forest will be negatively affected by mining and will not respond well to reclamation efforts in the short term (e.g., pileated woodpecker, ovenbird, scarlet tanager).
- Bird species using early successional habitats will use cover created by mine reclamation. In particular, the Forest Reclamation Approach will provide desirable habitats preferred over others such as traditional pine/locust plantings.
- Some of the early-successional bird species using reclaimed sites include declining species of special concern such as prairie warbler, field sparrow, yellow-breasted chat, and grasshopper sparrow.
- Our data on nesting success for indigo buntings and field sparrows indicate that these populations are potentially self-sustaining on these reclaimed sites (depending on juvenile and adult annual survival).
- The FRA approach provides habitat suitable for wildlife, and should be encouraged in future reclamation efforts.

Additional details regarding all bird species, habitat relationships, and additional management suggestions can be found in Carrozzino (2009), Carrozzino et al. (2011) and Latimer (2012).

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