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Conservation Effects Assessment Project (CEAP)
CEAP-Wildlife Conservation Insight

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Small Forest Openings Support Shrubland Birds and Native Bees in the Northeast

Summary of Findings

- Once prevalent on the landscape, early successional habitats are now rare in the northeastern United States. As a result, populations of many wildlife species that rely on these habitats (dominated by shrubs, young trees, grasses, and forbs) have declined.
- Group selection timber harvest can be used to create small forest openings (typically <1 ha) and has the potential to provide needed shrubland habitats within the parcelled forest ownerships of New England.
- Use of small forest openings by shrubland bird and bee communities was assessed across a range of forest opening sizes and configurations in southern New England to develop guidelines for optimizing the value of small forest openings to these high-priority wildlife resources.
- Minimum-area requirements for black-and-white warbler, common yellowthroat, chestnut-sided warbler, eastern towhee, and gray catbird were at most 0.23 ha, while indigo buntings and prairie warblers required larger openings (minimum-area requirements of 0.56 and 1.11 ha, respectively). Prairie warblers were more likely to be found in openings closer to large patches of habitat such as powerline corridors (>50 m wide) even if those openings were relatively small in size.
- Despite their inability to support all shrubland bird species in the region, small forest openings can provide habitat for several species of conservation concern if proper attention is given to promoting suitable microhabitat, patch, and landscape characteristics.
- Bee abundance and diversity were significantly higher in forest openings than in mature forest. Individual opening size did not affect bee abundance or diversity; however, bees were more abundant and diverse in openings and adjacent mature forest when there was more early successional habitat in the surrounding landscape. Bee abundance and diversity in forest openings tended to decrease with vegetation height and increase with a metric representing floral richness and abundance. In adjacent mature forests, eusocial, soft-wood-nesting, and small bees exhibited the opposite pattern, increasing with the succession of openings and decreasing with greater floral richness abundance within openings.
- Results suggest that the creation of small forest openings may help to promote bees both in openings and adjacent mature forest, with certain guilds benefitting more than others.

Background

Wildlife species that depend on early successional shrubland habitats have experienced severe population declines in eastern North America due to the loss of disturbance-dependent young forest habitats. Disturbances such as wind-throw, wildfire, beaver activity, and flooding, which once naturally sustained these ephemeral habitats, have largely been suppressed by humans. As a result, maintaining disturbance-dependent early successional habitats is now considered a conservation priority in the northeast. Mechanically treated wildlife openings can provide suitable habitat for high priority shrubland species, including birds (Chandler et al. 2009, King et al. 2009) and wild bees (Winfree et al. 2009). Silvicultural practices have been advocated for creating early

A forest gap of about 0.6 ha created by implementing silviculture. Gaps of this size are sufficient to support several shrubland bird species capable of using small forest openings.

successional habitat not only because they are effective in promoting many shrubland species, but also because management costs can be offset by timber revenue. Due to small woodland parcel ownership patterns and negative perceptions of clearcutting, a practice known as "group selection timber harvest," where groups of adjacent trees are removed from a mature forest matrix, may be an effective means of creating young forest habitat in New England. While forest openings created by group selection cuts provide habitat structure for shrubland birds, they are generally too small (< 1 ha) to support more area-sensitive shrubland bird species (Costello et al. 2000, Alterman et al. 2005).

Nevertheless, small forest openings still provide potential breeding habitat for species of regional concern that are less sensitive to patch size. Therefore, group selection can contribute to conservation on sites where the creation of patches large enough to support more area-sensitive species is not practical. Precise area thresholds for various shrubland nesting bird species need to be established to enable managers to understand the benefits of small forest openings to bird communities. Likewise, group selection has been shown to support more bees than mature forest or single-tree selection timber harvest methods (Proctor et al. 2012).

Landscape composition is considered a potentially important factor for shrubland birds (Schlossberg and King 2007), but studies have reported conflicting results. In general, studies have shown that landscape conditions may influence patch suitability for many shrubland-obligate bird species (e.g., Buffum and McKinney 2014), but also reveal the need for more detailed information to support the development of management guidelines.

Given the fact that silviculture is the dominant disturbance agent over much of the northeast and that there is reason to believe it will positively influence bee populations, a better understanding of how bees respond to a range of uneven-aged silvicultural practices, both in post-logging and adjacent habitats, will improve our ability to conserve and manage these key pollinators.

Assessment Partnership

In 2013, a Conservation Effects Assessment Project (CEAP) Wildlife Partnership was formed between NRCS and the University of Massachusetts to investigate the potential for small forest openings to support shrubland birds and native bees. Objectives were to (1) identify species-specific minimum-area requirements for shrubland birds capable of occupying small openings, (2) identify microhabitat-, patch-, and landscape-level factors that can promote shrubland bird occupancy of small forest openings, (3) compare the bee community within forest openings to that of adjacent mature forest to directly illustrate the impact of silviculture on bee communities relative to reference forest conditions, (4) identify stand-, patch-, and landscape-level factors influencing bee abundance and diversity in both openings and adjacent forest, (5) quantify bee abundance and diversity at a range of distances from forest openings to gauge the potential for openings to augment bee populations in adjacent mature forest, and (6) examine the habitat associations of individual bee species.

This CEAP conservation insight provides a summary of the assessment approach and findings. Additional details are available in the final report submitted to NRCS (Roberts and King 2016) as well as published journal articles on native bees (Roberts et al. 2017) and songbirds (Roberts and King 2017).

Assessment Approach

Study sites

This study was conducted in a heavily forested area of western Massachusetts during 2014 and 2015. The dominant forest type of this region is second-growth transitional hardwoods-white pine, consisting primarily of red maple, red oak, black birch, American beech, eastern hemlock, and white pine.

Most forest openings studied were created with group selection timber harvests, and openings contained seedlings and saplings of all adjacent tree species, as well as *Rubus* spp., mountain laurel, and numerous fern species. Residual debris from harvests was prevalent in all openings.

Study sites (90 openings in 2014 and 104 in 2015 for birds; 30 openings for bees in both years) were randomly selected from a list of 146 forest openings present in the study area. Openings ranged from 0.02–1.29 ha from timber harvests made between 2006 and 2010. To ensure openings represented the entire range of opening sizes, openings were chosen randomly from four bins representing different size ranges.

Bird surveys

Each year birds were surveyed three times from late May to early July with 10-minute, 50-m radius point counts at the center of each opening (Ralph et al. 1995). Surveys were conducted on calm days with no precipitation between 15 minutes after sunrise and 1100 hours. The location of all birds detected was recorded on scaled orthoimagery. Survey points were visited by at least two different technicians during each year in order to reduce observer bias (Ralph et al. 1995). Fly-overs and birds detected outside of the 50-m radius were not included in the analysis.

Bee surveys

Bee sampling took place during three periods: spring (April 26–May 14), summer (July 1–July 17), and late summer (August 23–September 8). Bees were collected using bowl traps (see photo on next page), which consisted of 96-milliliter plastic cups filled with water mixed with soap. To sample bees within openings, a transect of five sampling points 5 m apart was established in each opening 15 m from the forest and parallel to the opening edge. To sample bees in the forest, a second transect of 5 sample points 10 m apart was established starting 10 m from the opening and running perpendicular to the opening edge into the forest along east-west bearings to control for the effects of aspect (Matlack 1994). At each sampling point, three bowls, one white, one fluorescent yellow, and one fluorescent blue, were placed on the ground approximately 1 m apart. These colors have been shown to be most attractive to bees of eastern North America. Sampling was only conducted on sunny, calm days when the average temperature was above 10 °C. Forest transects were always placed such that surrounding sources of shrubland habitat were never closer to points along the transect than the focal opening. After 24 hours, bowls were collected and bees removed and preserved for later identification.

Sets of three bee bowl traps (one white, one fluorescent blue, and one fluorescent yellow) were placed on the ground about 1 meter apart in a triangular configuration at intervals of 5 meters in openings and 10 meters in mature forest.

Vegetation surveys

Vegetation structure and composition was measured at 20 random locations within each opening using random bearings and distances (1–25 m) starting from the approximate center of each opening. Plant species and maximum height for each plant that contacted a 1.5-cm-diameter vertical pole was recorded within four height classes: 0–0.5 m, 0.5–1.4 m, 1.4–3.0 m, and > 3.0 m. Number of flowers within a 1-m radius of each sampling point was recorded by species during each visit. To describe the floral community within openings, flowering species richness at each sampling point was determined and then summed across sample points in the opening, producing a course measure of both floral richness and abundance.

Patch and landscape metrics

Patch and landscape variables were calculated using FRAGSTATS, version 4 and ArcGIS 10.2.1 (Environmental Systems Research Institute, Inc., Redlands, CA). To facilitate analysis in FRAGSTATS, shapefiles delineating shrubland habitat boundaries were first created using ArcGIS and then rasterized using a 3-m cell size. Two patch-level metrics, area and Shape Index (SHAPE), were measured for each opening. SHAPE quantifies patch shape complexity by dividing the perimeter of a patch by the minimum possible perimeter of a patch equal in area. This eliminates bias associated with using the perimeter-to-area ratio metric on patches that vary in size.

Percentage of Landscape (PLAND) was used to measure the amount of shrubland habitat within the surrounding landscape. PLAND was calculated using a specified search-radius from the centroid of each opening. PLAND was calculated at 100-m, 200-m, 300-m, 400-m, and 500-m scales for bird analyses and 200-m and 500-m scales for bee analyses. The distance from each opening to the nearest large patch of shrubland habitat was determined using ArcGIS, where “large patches” were defined as any powerline corridor > 50-m wide or patches of shrubland habitat > 5 ha in area. Patches of this size are considered large enough to accommodate area-sensitive shrubland birds (King et al. 2009).

Data analysis

Shrubland bird occupancy was related to environmental variables using occupancy models. Bird analyses were restricted to males detected inside openings and to species that occurred in at least 10% of openings. Predictor variables used in bird analyses included percent broadleaf cover, median vegetation height, coefficient of variation (CV) of vegetation height, area, SHAPE, distance to large patch, and PLAND. A full description of the information-theoretic modeling approach used to analyze bird data is provided in Roberts and King (2016). The “minimum-area requirement” and “optimal area value” were determined for each species by identifying the area at which the probability of occurrence equaled 0.5 and 0.9 respectively (Shake et al. 2012).

Generalized linear mixed models (GLMM) were used to compare differences in bee abundance and diversity (Shannon’s Diversity Index) by habitat type, model abundance and diversity as a function of stand, patch, and landscape variables, model abundance and diversity in mature forest as a function of distance to openings, and examine habitat associations of individual species. See Roberts and King (2016) for a full description of bird and bee data analysis.

Results

Birds

Sixteen bird species considered core shrubland birds in New England (Schlossberg and King 2007) were detected in forest openings in 2014 and 2015. Only seven of these species had sufficient sample sizes for analysis: black-and-white warbler, common yellowthroat, chestnut-sided warbler, eastern towhee, gray catbird, indigo bunting, and prairie warbler. A sufficient sample size for indigo buntings was available only in 2014.

Relationships were detected between species occupancy and microhabitat-, patch-, and landscape-scale variables. Forest opening area was important for all species in both years. Of the seven species that showed a strong relationship with area, black-and-white warbler, common yellowthroat, chestnut-sided warbler, eastern towhee, and gray catbird were capable of occupying smaller openings, with

Table 1. Forest opening areas at which the probability of occurrence equaled 0.5 (minimum) and 0.9 (optimal). Data come from surveys conducted in forest openings in 2014 and 2015 in western Massachusetts.

Species	Forest opening area (ha)	
	Minimum	Optimal
Black-and-white warbler (BAWW)	0.12	0.18
Chestnut-sided warbler (CSWA)	NA	0.27
Common yellowthroat (COYE)	0.06	0.26
Eastern towhee (EATO)	0.11	0.31
Gray catbird (GRCA)	0.23	0.49
Indigo bunting (INBU)	0.56	0.7
Prairie warbler (PRWA)	1.11	NA

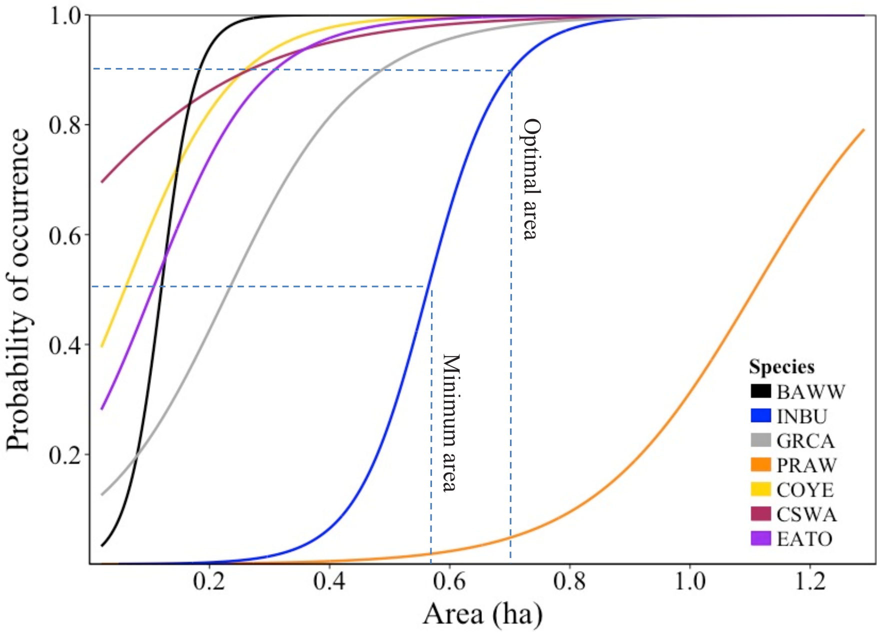

Figure 1. Occupancy model predictions demonstrating relationships between species occurrence and forest opening area. See table 1 (above) for species codes. Data come from surveys conducted in forest openings in 2014 and 2015 in western Massachusetts.

minimum-area requirements of at most 0.23 ha and optimal area values of at most 0.49 ha (Table 1, Fig. 1). Indigo bunting and prairie warbler exhibited greater area sensitivity, with minimum-area requirements of 0.56 ha and 1.11 ha, respectively (Table 1, Fig. 1). Indigo bunting displayed an optimal area value of 0.7 ha. An optimal area value for prairie warbler could not be determined because the probability of occurrence never exceeded 0.9. Prairie warblers appeared more likely to occupy smaller openings if they were near larger patches of shrubland habitat (Fig. 2).

Previous studies have shown that certain shrubland birds that are present in large forest openings are consistently absent from small patches, yet little progress had been made to identify area thresholds below which species are not likely to occur. This information is important to inform effective delivery of management practices aimed to benefit these species. Shake et al. (2012) determined minimum-area requirements for prairie warblers and yellow-breasted chats in North Carolina and determined there were distinct thresholds in patch area use for these species. This CEAP assessment supplements the efforts of Shake et al. (2012) with results for prairie warblers in a different region and also includes other species that occur in smaller openings. This assessment is the first to systematically sample a fine gradient of patch sizes small enough to determine both the occupancy thresholds for species with less restrictive area requirements as well as the value of these smaller openings for conserving more area-sensitive shrubland bird species.

Prairie warblers were the most area-sensitive species that occurred frequently enough in openings to be modeled and had an estimated minimum-area requirement of 1.11 ha. This estimate is nearly identical to the estimate of 1.1 ha by Shake et al. (2012) in North Carolina as well as the suggested opening size by Kerpez (1994) in Virginia, which was also 1.1 ha. Such consistency of estimated area requirements throughout the prairie warbler range suggests that this assessment's results are generalizable beyond the study area.

Historically, very little attention has been given to how proximity of large shrubland patches influence shrubland birds in smaller adjacent patches. In this assessment, prairie warblers occurred more frequently in openings closer to large patches of shrubland, indicating that shrubland habitats may be enhanced by proximity to large upland shrublands. Furthermore, prairie warblers were capable of occupying openings considerably smaller than their standard territory size (typically > 1.0 ha; Nolan 1978, DeGraaf and Yamasaki 2001) if the opening was located close to a large patch (Fig. 2). For example, one individual was found breeding in a 0.22-ha opening that was approximately 60 m from a powerline right-of-way. This observation suggests that prairie warblers have flexible territory sizes and are willing to sacrifice the benefits of larger territories for proximity to large patches. These findings also illustrate the importance of landscape context in shrubland bird communities.

Forest openings in this study were occupied by birds of high conservation concern. Six of the seven focal species (black-and-white warbler, common yellowthroat, chestnut-sided warbler, eastern towhee, indigo bunting, and prairie warbler) are experiencing significant regional population declines (Sauer et al. 2014). In addition, prairie warbler is listed as a species of continental conservation concern in the Partners in Flight North American Landbird Conservation Plan (Rosenberg et al. 2016). Therefore, while unable to support the full early successional bird community, openings as small as 0.23 ha can still provide habitat for at least five shrubland species, four of which are of conservation concern. This is particularly relevant to conservation because a larger proportion of forested parcels in southern New England can support openings 0.23 ha in size, and openings of this size are more likely to be acceptable to the public than larger clearcuts.

Bees

A total of 2,978 bees representing 5 families, 14 genera, and 76 identifiable bee species were collected from forest openings and adjacent forest habitat (Table 2). Nine species represented approximately 64% of all individuals. The two most common species were the spotted nomad bee (*Nomada maculata* - 456 individuals) and a green sweat bee *Augochlorella* (368 individuals). The majority of bees identified were polylectic (using a variety of nectar and pollen sources) bees (96% of individuals) and bees that nest belowground (66% of individuals). Solitary and eusocial bees were found in equal proportions (37% and 36%, respectively), while cleptoparasitic bees made up the remaining 27%. When habitats were examined separately, guild proportions were similar.

Bee abundance and diversity were significantly greater in openings than in adjacent forest (Fig. 3). Bee abundance and diversity in openings and adjacent mature forest were unrelated to patch area, but were positively related to the amount of early successional habitat on the landscape. Abundance and diversity of bees in both openings and adjacent mature forest showed non-linear unimodal responses to the amount of early successional habitat on the landscape within 500 m (Fig. 4). Bee abundance and diversity in the forest showed no significant relationship with distance to forest opening, but appeared to decline further from openings.

Bill Thompson, NPS

The prairie warbler is a neotropical migratory songbird that winters in the Caribbean and breeds in the northeast United States. Prairie warblers are shrubland habitat specialists typically associated with larger forest gaps. Their populations have been declining in the northeast for decades because of disruption of natural disturbance regimes and changes in forest management practices.

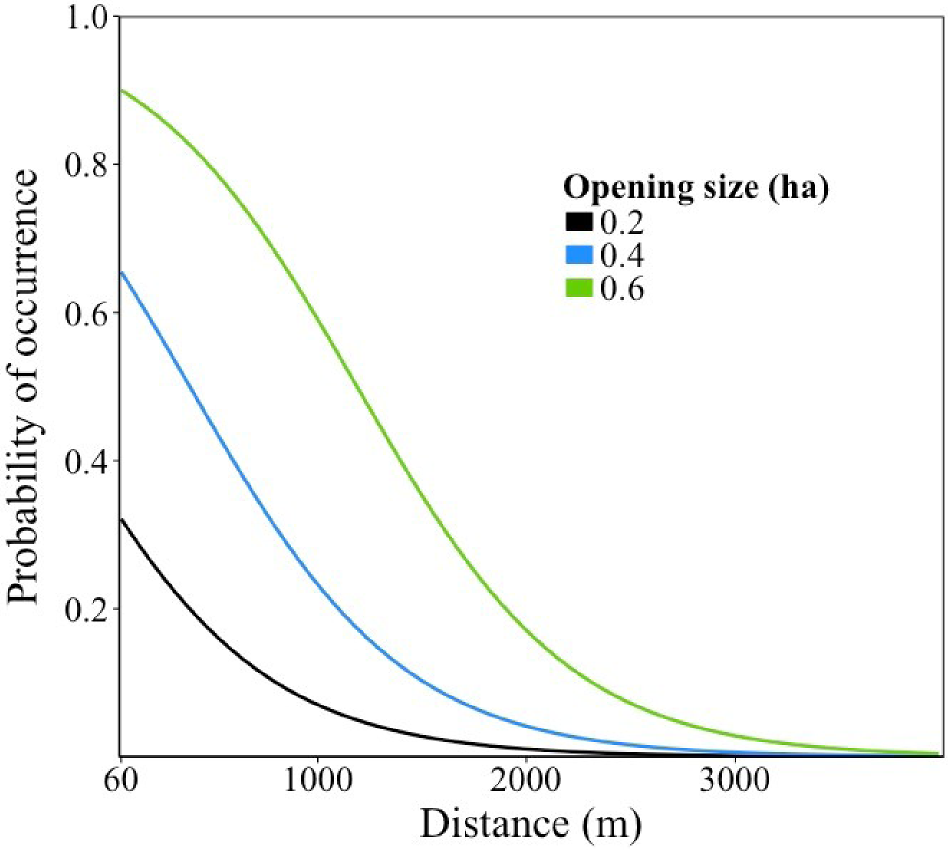

Figure 2. Occupancy model predictions demonstrating relationships between prairie warbler occurrence and the distance to the nearest large patch of shrubland habitat (>5 ha or powerline corridors >50 m wide) for different forest opening sizes (data from surveys conducted in forest openings in 2014 and 2015 in western Massachusetts).

Bees in openings were positively related to a metric representing floral richness and abundance and negatively related to vegetation height. Bees in adjacent mature forest were generally unrelated to microhabitat within openings; however, eusocial, soft-wood-nesting, and small bees displayed positive relationships with the height of vegetation within forest openings as well as negative relationships with floral richness and abundance within openings.

Seventeen bee species were abundant enough to compare between openings and mature forest. Of these species, 11 were significantly more abundant in openings than in mature forest. These species were *Andrena vicina, Augochlerella aurata, Ceratina calcarata, C. dupla, Lasioglossum cressonii, L. ephialtum, L. taylorae, N. luteoloides, N. maculata, Osmia atriventris,* and *O. pumila*. Two species, *L. coeruleum* and *L. versans,* were more abundant in mature forest than in openings, but only *L. versans* was significantly more abundant. Additional species that did not show strong associations with a particular habitat type were *Andrena carolina, A. uvulariae, L. planatum,* and *L. subviridatum.*

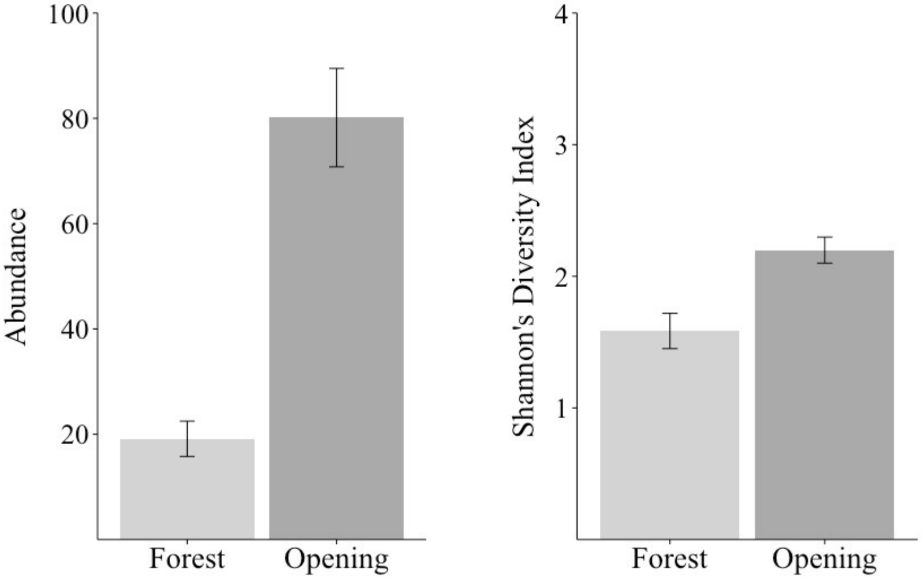

Figure 3. Mean bee abundance and diversity per transect in openings and mature forest. Bars represent standard error.

The findings that bee abundance and diversity were greater in forest openings compared to adjacent closed-canopy forest demonstrate the value of these practices to native bees and is consistent with the findings of Proctor et al. (2012) in Ontario. This is of interest from a conservation standpoint because of evidence that at least some native bee species are undergoing population declines (Bartomeus et al. 2013) and because habitat loss has been implicated as a potential cause of these declines (Potts et al. 2010).

In addition to their value in contributing to biodiversity, bees provide important pollination services for native plants, and loss of pollination services has been suggested as a potential

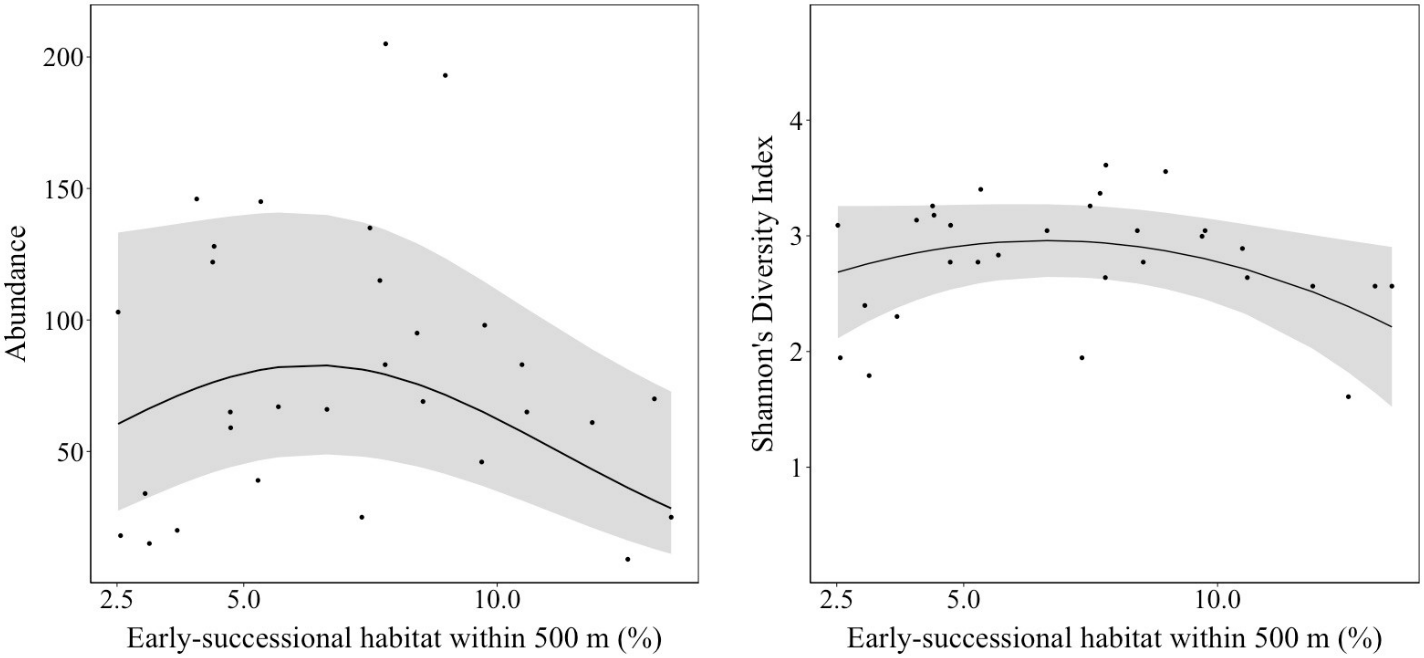

Figure 4. Bee abundance and Shannon's diversity index in openings in relation to the percent of the surrounding landscape that was early-successional habitat within 500 m (PLAND500). Lines represent the predicted values of fitted generalized linear mixed models that included a linear and quadratic term for PLAND500 as fixed effects and site as a random effect. Shaded regions indicate 95% confidence intervals.

A coppery-green metallic sweat bee *(Augochlorella aurata)* on a goldenrod. This is one of 74 species of native bees encountered in forest gaps, and like most species, it was significantly more abundant in gaps compared to adjacent closed-canopy forest.

cause of declines in native flora. The results of this assessment suggest that timber harvesting could be a potentially important tool for promoting bee populations and associated pollination services.

Landscape composition has been shown to be an important factor influencing bees, but few studies have examined the extent that early successional forest habitat landscape affects bees. In this assessment, all guilds in forest openings, apart from eusocial, pith-nesting, and medium-sized bees, displayed unimodal relationships with the amount of early successional habitat on the landscape within 500 m (Fig. 4). These nonlinear associations indicate that while early successional habitat beyond the boundaries of the treatment area can increase abundance and diversity, there appears to be an area threshold beyond which its influence subsides.

The positive relationship with early successional habitat suggests that silviculture promotes pollinators in adjacent forest and thus may translate to elevated pollinator services for flowering plants associated with mature forest. It is critical to recognize, however, that abundance and diversity followed a unimodal trend for the amount of early successional habitat at 500 m similar to that of bees within openings, indicating that extensive logging may not improve pollinator services if the resulting early successional cover is too great. Further attention needs to be given to examining this relationship and identifying when the benefits of early successional habitat may diminish.

This assessment supports evidence that local-scale factors are important in determining bee communities (Murray et al. 2012). Bees in openings were generally positively related to floral richness and abundance, and this finding is consistent with that of other studies (Roulston and Goodell 2011). The only guilds that showed no response to floral abundance were oligolectic bees, cleptoparasitic bees, soft-wood-nesting bees, and small bees. Oligoleges require certain types of pollen to provision their young and thus are more likely driven by the abundance of their host plants rather than the broader floral community. Similarly, cleptoparasites should be more driven by their host species as opposed to the floral community, especially since they do not provision their young. Small-bodied bees may have been primarily driven by the relative isolation of openings since body size is linked to shorter flight distances (Greenleaf et al. 2007).

Conclusions

The results of this assessment have important implications for the management of shrubland birds and native bees. In situations where the goal is to accommodate all of the focal bird species in this study, managers should create forest openings at least 1.11 ha in size. If openings of this size are not feasible operationally, openings as small as 0.23 ha can still provide habitat for species of high conservation concern.

Openings placed near preexisting large patches such as clearcuts >5 ha in size or powerline corridors that are at least 50-m wide can also maximize shrubland bird occurrence, particularly for prairie warblers. This assessment found the “minimum-area requirement” for prairie warblers to be similar with findings of studies in North Carolina and Virginia, suggesting these guidelines may be applicable throughout a large portion of the range of this species.

Public and private conservation and management entities have been encouraged to create habitat for pollinators, and plantings and pollinator gardens are recommended methods for achieving this goal (Vaughn et al. 2015). Although these methods are effective, they can be costly, especially when created at large spatial scales. This assessment demonstrates that forest management practices that create forest openings 0.08–1.29 ha within a landscape consisting of 5–15% early successional habitat can promote native bee communities, not only within openings, but also in surrounding mature forest.

Capture rates in openings in this study were lower than those of open meadow habitats dominated by perennial flowering plants (Gezon et al. 2015); nevertheless, the broad extent of silvicultural habitats throughout the Northeast suggest that the aggregate contribution of silviculture to pollinator populations in the region may be significant.

Table 2. Bee species collected with bowl traps in early spring, mid-summer, and late summer at 30 locations in western Massachusetts in 2014 and 2015.

Species	**Opening**		**Forest**		**Total**	**Origin**[a]	**Nest**[b]	**Diet**[c]	**Soc**[d]
	2014	**2015**	**2014**	**2015**					
Colletidae									
Colletes inaequalis	3	0	0	0	3	N	S	P	S
Hylaeus affinis	1	0	0	0	1	N	C	P	S
Hylaeus modestus	1	2	0	0	3	N	C	P	S
Halictidae									
Augochlorella aurata	269	79	13	7	368	N	S	P	E
Augochlora pura	9	8	2	0	19	N	SW	P	S
Agapostemon virescens	1	0	0	1	2	N	S	P	S
Sphecodes coronus	4	0	2	0	6	N	S	P	P
Sphecodes mandibularis	0	3	0	0	3	N	S	P	P
Sphecodes townesi	3	0	1	0	4	N	S	P	P
Halictus rubicundus	3	1	3	0	7	N	S	P	E
Lasioglossum acuminatum	4	2	3	2	11	N	S	P	S
Lasioglossum athabascense	1	0	0	0	1	N	S	P	S
Lasioglossum atwoodi	4	1	1	0	6	N	S	P	E
Lasioglossum coeruleum	14	26	17	30	87	N	SW	P	E
Lasioglossum coriaceum	11	3	5	2	21	N	S	P	S
Lasioglossum cressonii	26	9	6	3	44	N	SW	P	E
Lasioglossum ephialtum	29	4	3	1	37	N	S	P	E
Lasioglossum foxii	0	0	1	0	1	N	S	P	S
Lasioglossum laevissimum	2	1	1	0	4	N	S	P	E
Lasioglossum leucozonium	1	0	0	0	1	E	S	P	S
Lasioglossum nelumbonis	1	0	0	0	1	N	S	O	S
Lasioglossum nigroviride	6	0	0	0	6	N	S	P	E
Lasioglossum oblongum	4	0	1	2	7	N	SW	P	E
Lasioglossum planatum	14	29	6	6	55	N	S	P	E
Lasioglossum quebecense	11	1	11	2	25	N	S	P	S
Lasioglossum subviridatum	44	37	30	33	144	N	SW	P	E
Lasioglossum taylorae	66	53	15	4	138	N	S	P	E
Lasioglossum tegulare	2	2	0	1	5	N	S	P	E
Lasioglossum versans	10	0	18	4	32	N	S	P	E
Lasioglossum versatum	2	0	0	0	2	N	S	P	E
Lasioglossum viridatum	4	1	0	0	5	N	S	P	E
Lasioglossum spp.	25	44	9	18	96				
Andrenidae									
Andrena bradleyi	6	2	0	0	8	N	S	O	S
Andrena carlini	74	32	23	30	159	N	S	P	S
Andrena carolina	3	1	0	1	5	N	S	O	S
Andrena cressonii	3	0	0	0	3	N	S	P	S
Andrena forbesii	1	0	0	0	1	N	S	P	S
Andrena frigida	1	0	0	0	1	N	S	O	S
Andrena imitatrix	2	1	1	0	4	N	S	P	S
Andrena mandibularis	2	0	1	0	3	N	S	P	S
Andrena melanochroa	2	0	0	0	2	N	S	O	S
Andrena nigrihirta	1	3	0	0	4	N	S	P	S

Table 2--continued.

Andrena rufosignata	15	2	3	2	22	N	S	P	S
Andrena rugosa	6	0	7	0	13	N	S	P	S
Andrena tridens	9	0	8	0	17	N	S	P	S
Andrena uvulariae	31	17	10	28	86	N	S	O	S
Andrena vicina	40	1	3	0	44	N	S	P	S
Andrena violae	1	3	1	1	6	N	S	O	S
Andrena wilkella	0	1	0	0	1	E	S	P	S
Andrena spp.	0	2	0	0	2				S
Megachilidae									
Hoplitis producta	0	1	0	0	1	N	P	P	S
Osmia atriventris	73	71	21	6	171	N	C	P	S
Osmia bucephala	0	2	0	0	2	N	C	P	S
Osmia cornifrons	1	6	0	9	16	E	C	P	S
Osmia georgica	0	1	0	0	1	N	C	P	S
Osmia inspergens	3	2	0	0	5	N	C	P	S
Osmia lignaria	0	1	0	0	1	N	C	P	S
Osmia proxima	0	1	0	0	1	N	C	P	S
Osmia pumila	31	82	6	14	133	N	C	P	S
Osmia virga	2	5	0	0	7	N	C	O	S
Apidae									
Ceratina calcarata	27	123	1	15	166	N	P	P	S
Ceratina calcarata/dupla	1	0	0	0	1	N	P	P	S
Ceratina dupla	32	65	0	5	102	N	P	P	S
Ceratina mikmaqi	3	4	1	1	9	N	P	P	S
Nomada armatella	0	1	0	0	1	N	S	P	P
Nomada composita	2	0	1	0	3	N	S	P	P
Nomada cressonii	3	0	3	0	6	N	S	P	P
Nomada depressa	4	1	3	1	9	N	S	P	P
Nomada gracilis	4	1	0	1	6	N	S	P	P
Nomada gracilis/xanthura	1	0	0	0	1	N	S	P	P
Nomada illinoensis	0	1	0	0	1	N	S	P	P
Nomada imbricata	2	2	0	0	4	N	S	P	P
Nomada luteoloides	43	11	8	5	67	N	S	P	P
Nomada maculata	353	70	23	10	456	N	S	P	P
Nomada pygmaea	12	5	3	4	24	N	S	P	P
Nomada sayi/illinoensis	11	0	0	0	11	N	S	P	P
Nomada spp. (bidentate)[e]	117	25	15	17	174		S	P	P
Bombus bimaculatus	3	2	1	2	8	N	C	P	E
Bombus impatiens	20	5	2	2	29	N	C	P	E
Bombus perplexus	0	0	1	0	1	N	C	P	E
Bombus sandersoni	8	3	4	0	15	N	C	P	E
Bombus sandersoni/vagans	1	0	1	0	2	N	C	P	E
Bombus vagans	9	3	2	3	17	N	C	P	E
Unknown	1	0	0	0	1				
Total	1539	865	301	273	2978				

[a] Origin of species: exotic (E) or native (N).
[b] Nest substrate: cavity (C), pith(P), soil (S), soft wood (SW).
[c] Pollen-specificity: polylectic (P) or oligolectic (O).
[d] Sociality: eusocial (E), solitary (S), and parasitic (P).
[e] Bidentate *Nomada* that are not of the species *N. maculata* and could not be determined due to incomplete taxonomy.

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The primary authors of this CEAP conservation insight are H. Patrick Roberts and David King, University of Massachusetts and USDA Forest Service Northern Research Station.

For more information, go to www.nrcs.usda.gov/technical/NRI/ceap/, or contact Charlie Rewa, CEAP-Wildlife Component Leader, at charles.rewa@wdc.usda.gov.