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Immediate effects of chemical and mechanical soil preparation techniques on epigaeic arthropod assemblages during reclamation of in situ oil and gas sites in northern Alberta, Canada

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Abstract

Epigaeic arthropods have been used worldwide as indicators of post-disturbance recovery in many different types of ecosystems. We used them to evaluate the merit of different reclamation prescriptions applied to areas disturbed by oil and gas exploration and extraction. We compared the short-term effects of different mechanical and chemical site preparation techniques on the epigaeic arthropod fauna of previously reclaimed borrow pits in arrested succession with results from plots in untreated disturbed sites and undisturbed adjacent forest. In general, arthropod diversity increased and abundance decreased with the severity of soil disturbance involved in the silvicultural prescription. We place arthropod communities into four discrete groups reflected in the treatments and the environmental characteristics of the sites: forest species, grassland species, species primarily found in herbicide plots, and species found in disturbed soil. Individual borrow pits accounted for a significant amount of variation in faunal assemblages, suggesting that site location, vagaries of colonization, or disturbance history play a significant role in how the fauna recovers post disturbance. Our study provides baseline data required to document the trajectory of recovery in these sites. Long-term monitoring is essential to evaluate the relative usefulness of reclamation prescriptions in meeting targets established by law.

Key words: beetles, spiders, well-pad, herbicide, fertilizer, silviculture, native tree plantation, mounding, mixing

Résumé

Les arthropodes épigés ont été utilisés dans le monde entier comme indicateurs de la récupération après perturbation dans de nombreux types d'écosystèmes. Nous les avons utilisés pour évaluer le mérite de différentes mesures de remise en état appliquées aux zones perturbées par l'exploration et l'extraction de pétrole et de gaz. Nous avons comparé les effets à court terme de différentes techniques mécaniques et chimiques de préparation du site sur la faune d'arthropodes épigés de fosses d'emprunt précédemment remises en état, en succession arrêtée, avec les résultats de parcelles situées dans des zones perturbées non traitées et des forêts adjacentes non perturbées. En général, la diversité des arthropodes augmentait et l'abondance diminuait selon la gravité de la perturbation du sol impliquée dans le remède sylvicole. Nous plaçons les communautés d'arthropodes dans quatre groupes discrets reflétant les traitements et les caractéristiques environnementales des sites : les espèces de forêt, les espèces de prairie, les espèces principalement trouvées dans les parcelles d'herbicide, et les espèces trouvées dans le sol perturbé. Les fosses d'emprunt individuelles ont représenté une part importante de la variation des assemblages faunistiques, ce qui suggère que l'emplacement du site, les aléas de la colonisation ou l'historique des perturbations jouent un rôle important dans la façon dont la faune se rétablit après une perturbation. Notre étude fournit les données de base nécessaires pour documenter la trajectoire de remise en état de ces sites. Le suivi à long terme est essentiel pour évaluer l'utilité relative des techniques de remise en état pour atteindre les objectifs fixés par la loi. [Traduit par la Rédaction]

Mots-clés : coléoptères, araignées, coussinet de puits, herbicide, engrais, sylviculture, plantation d'arbres indigènes, buttage, mélange

Introduction

Canada's boreal forest is constantly under pressure from multiple natural and anthropogenic disturbances. Natural disturbances such as forest wildfires (Weber and Stocks 1998; Bergeron et al. 2004; Pinzon et al. 2021), insect and disease outbreaks coupled with climate change (Volney and Fleming 2000; Chen et al. 2018), and anthropogenic disturbances such as harvesting, road construction, and oil and natural gas development (Venier et al. 2014) are resulting in a combination of changing of habitat or outright habitat loss (Pasher et al. 2013). Of the 552 million ha of boreal ecosystem in Canada, approximately 24 million ha has been affected by anthropogenic disturbance (Pasher et al. 2013).

There are many different types of infrastructure associated with oil and gas development including roads, seismic lines, borrow pits, well pads, and processing facilities. Much of this infrastructure requires a level and solid base resulting in the removal of overlying vegetation and the redistribution of large amounts of soil. Development of these sites involves complete removal of trees and clearing of forest vegetation, followed by the full removal and stock piling of surface soil, and levelling of the subsurfaces. In addition to the complete disruption of soil ecosystem services, displacement of surface soils also removes seedbanks of native vegetation as well as all of the organic material from the site (Lupardus et al. 2019). Other disturbed areas are created in support of these developments such as "borrow pits", where the soil is removed and donated to create the base for roads and well pads. Another consequence of the levelling procedure is soil compaction from heavy equipment travelling across these sites. Eventually, however, government regulations require that these sites are reclaimed back to some form of "natural" landscape (ESRD 2013). For example, in Alberta, Canada, reclaimed sites must be certified as having been returned to "equivalent land capability", meaning that soil, vegetation, and hydrology are returned to the extent that the land can support land uses similar to what existed prior to disturbance (Government of Alberta 1995; Powter et al. 2012; ESRD 2013).

Reclamation typically involves the removal of infrastructure, remediation of any contaminated soils (if they exist), replacement of salvaged soils, recontouring of the surface, and revegetation of the site (ESRD 2013). Current practice emphasizes revegetating sites with native plant species (Errington and Pinno 2016) and supplementing sites with various types of organic material (Mackenzie and Naeth 2010; Pinno et al. 2012; Dhal et al. 2018); however, early attempts at site reclamation primarily focused on prevention of soil erosion using revegetation with agronomic grass species such as fescue, brome, timothy, and clover species (Strong 2000; Powter et al. 2012). The addition of the "reclamation mix" of grasses on older reclamation sites resulted in variable reclamation trajectories and outcomes. Some reclaimed areas would "stall", often resulting in the succession of non-native herbaceous vegetation or grasslands that inhibited the establishment of native tree and shrub species by seed from the undisturbed forests along the edges of these sites. Ultimately some of these sites failed to recover conditions previous to disturbance, resulting in a state of arrested succession.

Because oil and gas companies are required to reclaim sites that have been disturbed (Government of Alberta 1995; Powter et al. 2012; ESRD 2013), many sites that are unsuccessfully reclaimed are subjected to a subsequent series of techniques to get them back onto a successful reclamation trajectory. Depending on the company and location, treatments range from replanting trees to resetting succession by application of chemical herbicides to kill noxious weeds and non-native plant species (Lieffers et al. 1993; Small et al. 2018). In some situations, even biocontrol methods such as specialized phytophagous insects have been used to control weeds on site (J. Hammond, pers. obs.). In extreme cases, site treatments typically used by the forest industry for forest regeneration after harvesting may be required. For example, in addition to fertilization and chemical weed control, mounding and mixing can be used to improve seedling establishment and growth. A mound is created by an excavator equipped with a spoon-shaped bucket that is pulled through the soil just below the roots and then flipped over to create an elevated planting site with soil on the top and the grass sandwiched beneath (Sutton 1993). Mixing uses an industrial rototiller or similar implement to incorporate the vegetation and other organic matter into the mineral soil to loosen compacted soil and control competition from weeds.

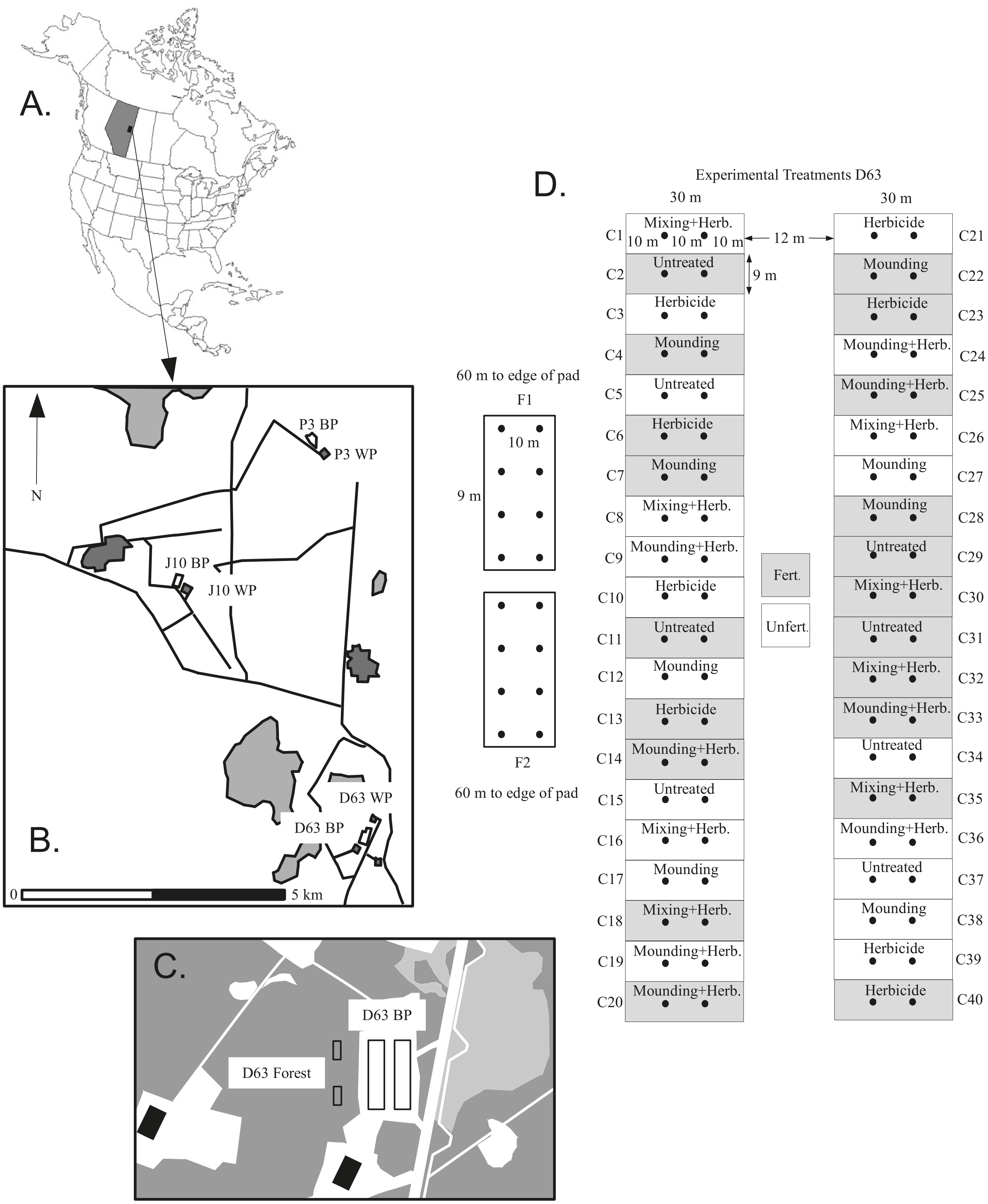
Traditionally reclamation success was based mainly on building appropriate cover on reclaimed sites, with the idea that "…if you build it they will come…." However, although aspen and spruce trees can be grown as ornamental trees such plantings do not constitute a functional forest. More recent efforts take a holistic "ecosystem approach" to reclamation based on an understanding of the complex connections among ecosystem services (Hammond et al. 2018) during recovery trajectories. For example, soil- and litter-dwelling arthropods have been used as model organisms to understand recovery from forest disturbances like wildfire (Buddle et al. 2006; Hammond et al. 2017; Pinzon et al. 2021), forest harvesting (Buddle et al. 2006; Niemelä et al. 2006; Pinzon et al. 2012; Hammond et al. 2017), and more recently oil sands mining and wellpad reclamation (Battigelli 2011; Hammond et al. 2018; Lupardus et al. 2021). Arthropods are good indicators of forest health because they are (1) sensitive to disturbance, (2) highly mobile and can redistribute themselves relatively quickly, (3) involved in many ecosystem processes (e.g., nutrient turnover), (4) species rich and abundant, (5) responsive to both soil and vegetation properties, (6) relatively easily and inexpensively sampled, and, finally, (7) much information is known about the biology of some of the taxa that are relatively easy to identify. The goals of the present study were to compare the composition of arthropod assemblages between borrow pits that suffered arrested succession after reclamation and adjacent undisturbed forest fragments and to examine the immediate effects on arthropod assemblages of several silvicultural techniques used to reclaim these sites.

Materials and methods

Study sites

This study was conducted at Imperial Oil's Cold Lake thermal in situ heavy oil facility (53°34.970′N, 110°28.252′W) approximately 24 km northwest of the town of Cold Lake, Alberta (Fig. 1). The Cold Lake facility began production in 1975 and is the longest running processing plant in northeastern Alberta. The area is comprised of gentle to abrupt undulating to rolling glaciofluvial plain, composed of sandy

Fig. 1. Locations of the three reclamation trials (D63, J10, P3) at Imperial Oil's Cold Lake thermal in situ heavy oil facility near Cold Lake, Alberta. The D63 reclamation has been expanded to show an example of the silvicultural treatment layout and adjacent forest block. Black circles represent the pitfall trap locations. BP = borrow pit; C = experimental treatment compartment. A. Location of Imperial Oil study site in Alberta. B. Locations of each of the three reclamation trials. C and D. Schematic of the D63 reclamation trial. (A) Adapted from North America (2000) base map, scale 1:10 000 000, available from Natural Resources Canada, https://open.canada.ca/data/en/dataset/5f69f937-6109-5a49-9d46-7db53cffa6dd. https://ftp.geogratis.gc.ca/pub/nrcan_rncan/raster/atlas/eng/reference/n_america/mcr_0031_2000.jpg, open government license. (B and C) Traced from ©CNES/Airbus imagery (2022) available through Google Earth.



alluvial, rapidly drained soils (Kocaoglu 1975). Upland forests occurring in this area consist of mixes of trembling aspen (*Populus tremuloides* Michaux), white spruce (*Picea glauca* [Moench] Voss), jack pine (*Pinus banksiana* Lambert), and a lesser percentage of balsam poplar (*Populus balsamifera* Linnaeus), whereas lowland forests are mainly mixes of black spruce (*Picea mariana* (Mill.) BSP) and tamarack (*Larix laricina* (Du Roi) K. Koch).

Our work focused on three reclaimed borrow pits (D63, J10, and P3) that had been reclaimed approximately 25–30 years ago, using standard methods for the time. At each of the three sites, the topsoil was stripped using a bulldozer and stockpiled along the edges of the site. The original reclamation involved contouring by bulldozers and other heavy equipment, and then according to the practice of the time levelling and smoothing the sites to obtain an even surface before seeding with a grass seed mix of timothy (*Phleum pretense* Linnaeus), fescue (*Festuca ovina* Linnaeus), brome (*Bromus inermis* Leysser), and sweet clover (*Trifolium hybridum* Linnaeus). The standard practice of the day was to stabilize the soil and create a green cover of vegetation. Succession stalled on all three of these borrow pits as natural seed flow from adjacent forest did not establish native tree species.

The first trial (D63) was set up in 2016, and arthropods were sampled in 2017. The D63 borrow pit is 25–30 years old, approximately 4 ha in size, with its longitudinal axis running north to south (Fig. 1). The two other trials (J10 and P3) were set up in 2018 with subsequent arthropod sampling in 2019. J10 is approximately 30 years old, approximately 2.8 ha in size, with its longitudinal axis running northeast to southwest. P3 is approximately 30 years old, approximately 3.2 ha in size, with its longitudinal axis running northwest to southeast. The three borrow pits are 3.8–7.8 km away from each other. We sampled both the reclaimed areas and adjacent forest as these provided the seed sources for colonization by native tree species. Each of the forest sites was either directly adjacent to or within 300 m of the reclaimed site. Forest stands ranged in size from 2.8 to 25 ha, were >60 years old, and were aspen-dominated mixed stands which included white spruce, balsam poplar, and paper birch.

Experimental design and silvicultural treatments

Each of the three borrow pits was divided into 40 experimental plots arranged in two or three parallel rectangular sections oriented along the longitudinal axis of the reclaimed site (Fig. 1). The parallel rectangular sections were separated by a 12 m travel corridor, and each section contained 10–20 experimental plots; each plot measuring 9 m × 30 m. There were eight replicates of each treatment applied to the 40 plots as follows:

- Treatment 1: Untreated (Ut) — no mechanical or herbicide treatment applied.
- Treatment 2: Herbicide alone (Hb) — herbicide was applied in 18 strips of 2 m × 1.5 m, each separated by 1 m of untreated in each plot. Herbicide was applied at 6 $L{\cdot}ha^{-1}$ of glyphosate (Roundup Transorb), sprayed at the time of mechanical site preparation and then reapplied 2 months post-treatment.
- Treatment 3: Mounding (Md) — inverted mineral mounds were created using a Tysea Manufacturing mounding rake mounted on a Caterpillar 320E excavator to establish elevated platforms of mineral soil at c. 2 m intervals for planting.
- Treatment 4: Mounding + herbicide (MdHb) — same as above except that a 2% solution of glyphosate (Round-Up Transorb) was sprayed on the mound and around the edges of the excavation approximately 2 months post mounding to allow the vegetation to sprout.
- Treatment 5: Mixing + herbicide (MxHb) — the soil was mixed using a Bobcat bidirectional tiller mounted on a Cat-tracked skidsteer loader. The mixing was done by moving forward approximately 2 m with the tines turning in direction of travel, and then reversing the tine direction and pulling back thus creating an elevated mixed strip approximately 15–20 cm high by ~1.8 m long. The strip was situated in the middle of the tilled area. Herbicide application occurred 2 months post mixing as described above.

Soil chemical analyses conducted prior to the trials indicated that the soil of the reclaimed areas was deficient in nitrogen and phosphorus and therefore the treatments were further partitioned into fertilized or non-fertilized plots. One fertilizer tablet [20-10-05 planting tablets (Forestry Suppliers)] was pushed into the soil approximately 5 cm away from the stem of each planted seedling or cutting in four of the eight replicates at each borrow pit. These slow release tablets are effective for approximately 2 years.

The experimental plots were planted with a combination of tree and shrub species as follows: green alder (*Alnus alnobetula* ssp. *crispa* (Aiton) Raus) and balsam poplar (*Populus balsamifera* L.) 20-cm-long 1-year-old stem cuttings and 1-year-old white spruce (*Picea glauca*) seedlings grown in Beaver Plastics 512A Styroblock, were hand planted in spring. Planting spots were randomly located on the untreated plots (Ut). One each of each species was planted on the top of each mound (Md, MdHb), in each herbicide alone strip (Hb) and in each mixing plus herbicide (MxHb) patch, for a total of 18 seedlings of each species planted in each treatment plot.

Arthropod sampling

Epigaeic arthropods were sampled using pitfall traps consisting of a 250 mL white plastic inner cup nested within a 500 mL white plastic outer sleeve dug into the soil, and then protected from dilution from rain with a 10 cm × 10 cm elevated plastic cover (Spence and Niemelä 1994). Approximately 100 mL of automotive-grade propylene glycol (AMSOIL, Superior, WI, USA) was added to each pitfall trap as a killing agent and specimen preservative. In addition, Bittrex (12.5 $mg{\cdot}L^{-1}$; Webster et al. 2012) was added to each trap to deter wildlife from disturbing the pitfall traps. Two pitfall traps were placed near the center of each plot, each trap 10 m from the edge and 10 m from each other (Fig. 1). Two sets of eight pitfall traps were set up in the adjacent forest patch in a similar design as the treatment blocks, where traps were placed approximately 10 m from each other, and

60 m away from the forest edge. Pitfall catches were collected every 10–20 days from traps run continuously from 30 mol·Lay^{-1} to 1 September 2017 (maximum of 93 trap days) at D63; 14 mol·Lay^{-1} to 10 September 2019 (maximum of 119 trap days) at J10; and 15 mol·Lay^{-1} to 9 September 2019 (maximum of 117 trap days) at P3.

Ground beetles (Carabidae), rove beetles (Staphylinidae), and spiders (Araneae) were sorted and tallied from each pitfall trap sample and adult specimens of each taxon were identified to species using the following taxonomic literature and consultation with reference insect collections: (1) Carabidae: primarily Lindroth 1961-69; Noonan 1991; Pearson et al. 2006; (2) Staphylinidae: Campbell (1969, 1973*a*, 1973*b*, 1979, 1980, 1982*a*, 1982*b*, 1983, 1984, 1991); Cuccodoro and Löbl 1996; Herman 1975; and Smetana (1971, 1981, 1982, 1995); and (3) Araneae: Dondale and Redner (1978, 1982, 1990); Dondale and Platnick (1992); Dondale et al. (2003); and Paquin and Dupérré (2003). Specimens in the rove beetle subfamily Aleocharinae were not identified nor considered in analyses in this study due to the lack of taxonomic resources to identify them; however, they have been put aside for later consideration. Some genera of rove beetles are in need of revision, and in these few cases we identified individuals to morpho-species within a genus. Beetle nomenclature follows Bousquet et al. (2013) and spider nomenclature follows the World Spider Catalog (2021). Voucher specimens of each taxon have been deposited at the Northern Forest Research Collection in Edmonton, Alberta.

Biotic and abiotic data

In addition to surveying the arthropods, we assessed several other biotic and abiotic characteristics of the habitats surrounding each pitfall trap. The depth of the organic component of the soil was measured from the extracted pitfall trap "plug". The air temperature was sampled 1.3 m above the ground and soil temperature at 2.5 cm depth with a digital thermometer. Photosynthetic active radiation (PAR; wavelengths between 400 and 700 nm) was measured using an AccuPAR PAR/LAI Ceptometer (model LP-80) both at the soil surface and 1.3 m above the trap and recorded from each pitfall trap location during each trap collection throughout the summer, weather permitting. These data were used to calculate a soil temperature index (soil temperature/air temperature) and light transmission index (PAR soil surface/PAR breast height) to help account for different temperature and light conditions at each trap throughout the day and season. Biotic attributes such as total bare soil area, litter, total plant cover, and coarse woody material (CWM) cover and tree, shrub, forb, grass, sedge, and moss covers were assessed as visual estimates of % cover on a 1 m^2 circular plot centered on each pitfall trap.

Data analyses

Site data

Principal components analysis (PCA) of the environmental variables was conducted to ascertain whether sites within each silvicultural treatment formed discrete units and to determine which of the variables were best correlated with their particular-site treatments. Prior to analysis, the variables were standardized (mean = 0, variance = 1) to account for differences in measurement units (Borcard et al. 2018). Borrow pits were used as a conditional variable (block) to account for the variation in observations among the different borrow pits.

Arthropod catch

Sampling effort varies among individual traps due to differences in establishment date and minor trap disturbance; therefore, trap catches for each species were standardized to 120 trap days (raw catch of each species per trap × [120/actual number of trapping days per trap]). Differences in standardized abundance of each taxon among treatments were examined using generalized linear mixed-effects models. Samples from pitfall traps were classified by silvicultural treatment, and differences in standardized abundances were assessed using treatment × fertilization as a fixed factor and site (block) as a random factor. Models based on Poisson, quasi-Poisson, and negative binomial distributions were compared using analysis of deviance using Type II Wald chi-square tests, resulting in the same underlying residual distribution (negative binomial) for all taxa. Multiple comparisons ($\alpha = 0.05$) were carried out using Tukey's contrasts with Holm's P-value adjustment.

Arthropod species richness and diversity

Species richness and diversity were examined using Hill's numbers (Hill 1973): species richness (q_0, S) which weights all species equally and the exponential of Shannon's entropy (q_1, H) which weights species relative to their abundance (Chao et al. 2014). In addition, Pielou species evenness (J) was calculated as $\ln(H)/\ln(S)$, resulting in values ranging from 0 to 1, with 0 representing no evenness (i.e., assemblage dominated by 1 or few species) and 1 representing complete species evenness (i.e., all species represented equally in the assemblage). Relationships of patterns in arthropod species diversity and richness by reclamation treatment were examined using coverage-based rarefaction (Chao and Jost 2012). This method uses minimum sample completeness (coverage) to estimate species richness rather than the traditional lowest number of individuals among samples for comparison. Coverage equates to the percentage of the total number of individuals that belong to a species at the level of comparison. Coverage and species richness estimates (±95% confidence interval) were calculated at 93.4% (ground beetles), 95.1% (rove beetles), and 94.2% (spiders) completeness after 100 bootstrap randomizations extrapolated at twice the observed richness. Non-overlapping 95% confidence intervals were considered to be significant at $\alpha = 0.05$.

Arthropod assemblages

We examined the similarity of arthropod taxa among each of the experimental plots and forests using the Bray–Curtis index, based on pairwise dissimilarities calculated with standardized abundance for each species (transformed to % similarity (1 − dissimilarity). These matrices were then used in cluster analysis using unweighted arithmetic averaging to depict faunal similarity among sites based only on the relative abundance of arthropod species.

Response patterns due to silvicultural treatments

We examined relationships between the arthropod catch data, the explanatory variables, and environmental data using redundancy analysis (RDA; Legendre and Legendre 2012). RDA is a multivariate analog of regression analysis in which the response variable is a matrix of arthropod catches by species for each plot. For RDA, arthropod catch was limited to species with a standardized catch greater than five individuals to reduce the influence of uncommon species on the ordination. Catches were Hellinger transformed prior to fitting the model to improve the RDA solution (Legendre and Gallagher 2001). We first examined the relationship of the explanatory variables (borrow pit, treatment, and fertilization) on the arthropod catch data and determined whether there were patterns of influence among these classification variables. We then examined the relationships of the arthropod catch data to the specific environmental variables. We used borrow pits as a conditional variable (block) in the environmental model to account for differences among the individual borrow pits.

Significant indicator species were identified using the approach in De Cáceres et al. (2010). We used a group-equalized indicator value to account for differences in sampling size between the site preparation treatments. *P*-values were corrected for multiple comparisons using the Holm method. Significant indicator species (indicator value of at least 0.80, at $\alpha = 0.05$) were identified after 4999 permutations.

All data analyses were conducted in R version 4.1.0 (R Core team 2021) using the following packages: PCA, RDA, and cluster analysis were conducted using vegan v2.5–6 (Oksanen et al. 2015), ade4 v1.7–16 (Dray and Dufour 2007), adegraphics v1.0–15 (Dray et al. 2017), adespatial v0.3–8 (Dray et al. 2020), ape v5.4–1 (Paradis et al. 2004), SoDA v1.0–6.1 (Chambers 2020); generalized linear mixed-effects model analysis was conducted using lme4 v1.1–26 (Bates et al. 2015); coverage-based rarefaction was conducted using iNEXT v2.0.20 (Hsieh et al. 2016); and indicator species analysis was conducted using indicspecies v1.7.9 (De Cáceres and Legendre 2009).

Results

Treatment characteristics

The forest sites and reclamation treatments were widely separated in the PCA based on the environmental variables that we considered. However, even the replicates of untreated sites and the four reclamation treatments were relatively discrete units in ordination space, with significant overlap only between the two treatments that received herbicide (Fig. 2A). The conditional variable, borrow pit, explained 8.6% of the differences among observations. The first axis of the PCA explained the difference between forest stands and reclaimed areas (PC1 = 32.1%). The second axis showed a relationship with plant cover (PC2 = 21.0%) with more highly vegetated silvicultural treatments at the top and more barren sites towards the bottom of the plot. Environmental variables with the highest contribution to PC1 included forest attributes such as CWM, tree, shrub, and moss covers, and organic material depth in the soil; soil temperature was higher in the reclaimed pads (Fig. 2A). Environmental variables with the highest contribution to PC2 included vegetation attributes such as total plant, grass, and forb cover and the amount of litter material, bare soil, and light reaching the ground (Fig. 2A).

Examination of the environmental variables resulted in the separation of the silvicultural treatments involving soil disturbance from the untreated areas and those that involved herbicide treatments (Fig. 2B). In this ordination the conditional variable site explained 11.0% of the variation among observations. The first PCA axis separated treatments based on the amount of vegetation cover (PC1 = 24.2%), with the highest contribution made by the total plant, grass, and forb cover on the left of the ordinate, as well as treatments with high litter amounts and more direct light on the right of the ordinate (Fig. 2B). The second PCA axis separated treatments based on the amount of soil disturbance (PC2 = 22.7%), with the non-treated and herbicide treated sites above PC2 and the heavily disturbed soil treatments, mounding and mixing, below the axis (Fig. 2B). Environmental variables with the highest contribution to PC2 included the total cover of bare soil, soil temperature, and the amount of organic matter in the soil (Fig. 2B).

Arthropod catch

A large number of epigaeic arthropods were collected, including 6582 adult ground beetles, 9426 non-aleocharine rove beetles, and 14 778 spiders that were identified as species (Appendix Table A1). Catches of ground beetles were highest in the forest stands (3732); while rove beetle and spider catches were highest in the reclaimed areas (5293 and 11 968, respectively). Mean standardized catch of ground beetles was similar among all of the silvicultural treatments ($\chi^2_{\text{treat} \times \text{fert}} = 2.98$, $P = 0.56$; Fig. 3). Rove beetle mean standardized abundance was highest in the untreated plots and lowest in the mixing + herbicide treatments ($\chi^2_{\text{treat}} = 53.07$, $P < 0.01$; Fig. 3). The mean standardized catch of spiders was significantly higher in the untreated plots and herbicide treatments and lowest in the treatments with soil disturbance ($\chi^2_{\text{treat}} = 443.96$, $P < 0.01$; Fig. 3). Increasing levels of soil disturbance reduced catches of rove beetles and spiders but had no significant effect on ground beetle catches.

Species richness, diversity, and eveness

Ground beetle

A total of 73 species of ground beetles were collected during this study, of which 27 species were collected in the forest stands, 66 species collected in the borrow pits, and 20 species collected in both the forest and borrow pits (Appendix

Fig. 2. Principal components analysis of environmental variables averaged by block for (A) all study areas and (B) treated blocks 1-year post-treatment near Cold Lake, Alberta. Sites were used as a conditional variable. Ellipses represent the centroid of the group average for each treatment. Treatment abbreviations: Ut = untreated; Hb = herbicide; Md = mounding; MdHb = mounding + herbicide; and MxHb = mixing + herbicide. Environmental variables include: PAR = light; Soil_T = soil temperature; OMD = organic matter depth; CWM = coarse woody material; Bare = bare soil; Litter = total litter cover; Plant = total plant cover; Tree = overstory tree cover; Shrub = shrub cover; Forb = forb cover; Grass = grass cover; Sedge = sedge cover; Moss = moss cover.

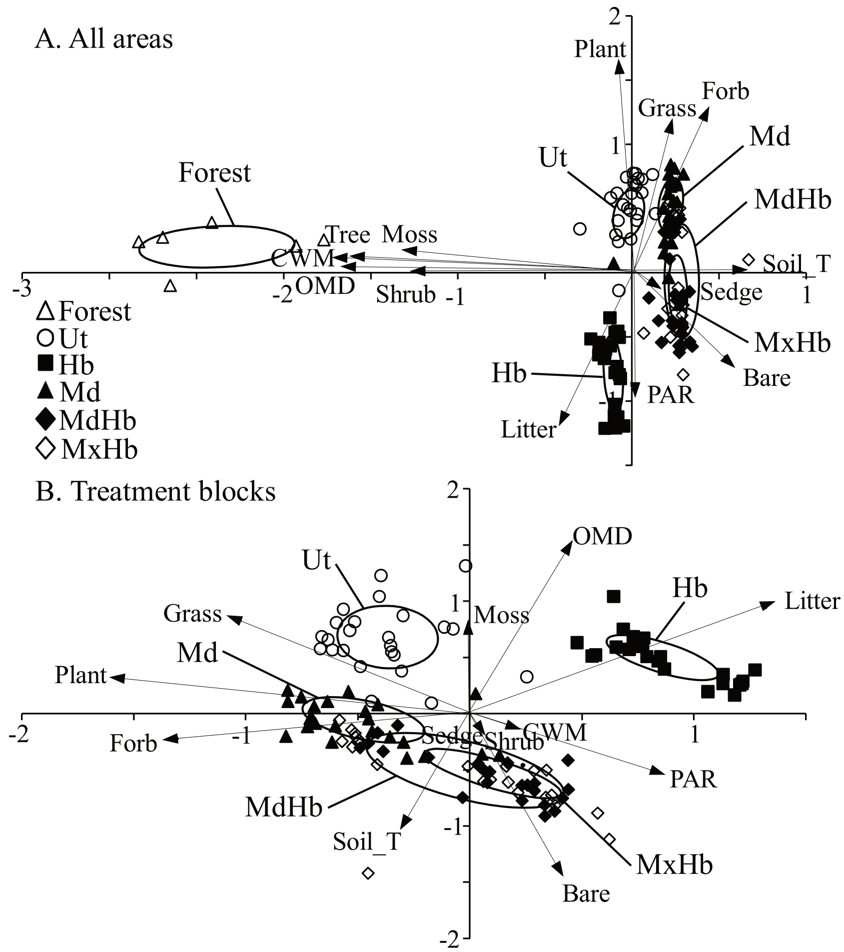


Table A1). In the sample pooled across treatments, 20 species were represented by one individual (singletons), five species represented by two individuals (doubletons), and eight species (*Platynus decentis* (Say), *Calathus ingratus* Dejean, *Pterostichus adstrictus* Eschsoltz, *Agonum retractum* LeConte, *Synuchus impunctatus* (Say), *Amara obesa* (Say), *Pt. pensylvanicus* LeConte, and *Poecilus lucublandus* (Say)) each accounted for >5% of the overall catch (Appendix Table A1).

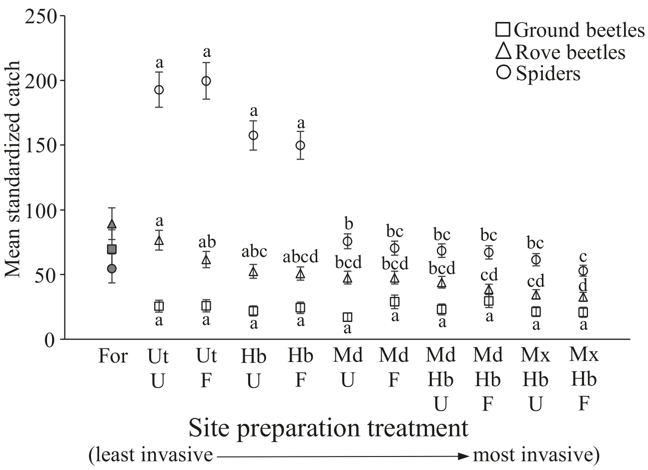
At a sample coverage of 93.4% of the total Carabidae assemblage, species richness was significantly higher in the reclaimed areas than in the forest stands; and within the reclaimed borrow pits, species richness was higher in the treatments with soil disturbance rather than in the herbicide or untreated plots (Fig. 4A). Species diversity was similarly higher in the reclaimed borrow pits than in the forest stands, but not overall higher in any of the treatment plots (Fig. 4A). Carabidae assemblage evenness was highest in the forest stands, with only a slight decrease in the treatment plots (Fig. 4A).

Rove beetle

There were 119 non-aleocharine rove beetle species collected during this study, of which 64 species were collected in the forest stands, 108 species collected in the borrow pits, and 53 species collected from both forest and borrow pits (Appendix Table A1). In the sample pooled across treatments, there was a total of 30 singletons, five doubletons, and three species (*Ischnosoma splendidum* (Gravenhorst), *Tachinus fumipennis* (Say), and *Eucnecosum brunnescens* (Sahlberg)) with catches greater than 5% of the overall catch (Appendix Table A1).

At a sample coverage of 95.1% of the total rove beetle assemblage all three metrics, species richness, diversity, and evenness increased with increasing treatment effort (Fig. 4B). Species richness of rove beetles was lower in the forest stands, and significantly increased in both the chemical and mechanical treated plots (Fig. 4B); however, species diversity was highest in the forest stands, and significantly lower in the borrow pits (Fig. 4B). Rove beetle assemblage

Fig. 3. Mean standardized catches of ground beetles, rove beetles, and spiders collected by pitfall traps in different silvicultural site preparation treatments of reclaimed borrow pits near Cold Lake, Alberta. Means with the same letter are not significantly different at $\alpha = 0.05$. Treatments: Ut = untreated; Hb = herbicide; Md = mounding; U = unfertilized; F = fertilized; For = adjacent undisturbed forest blocks.



evenness was higher in the forest stands and increased with the intensity of silvicultural treatment in the borrow pits (Fig. 4B).

Spider

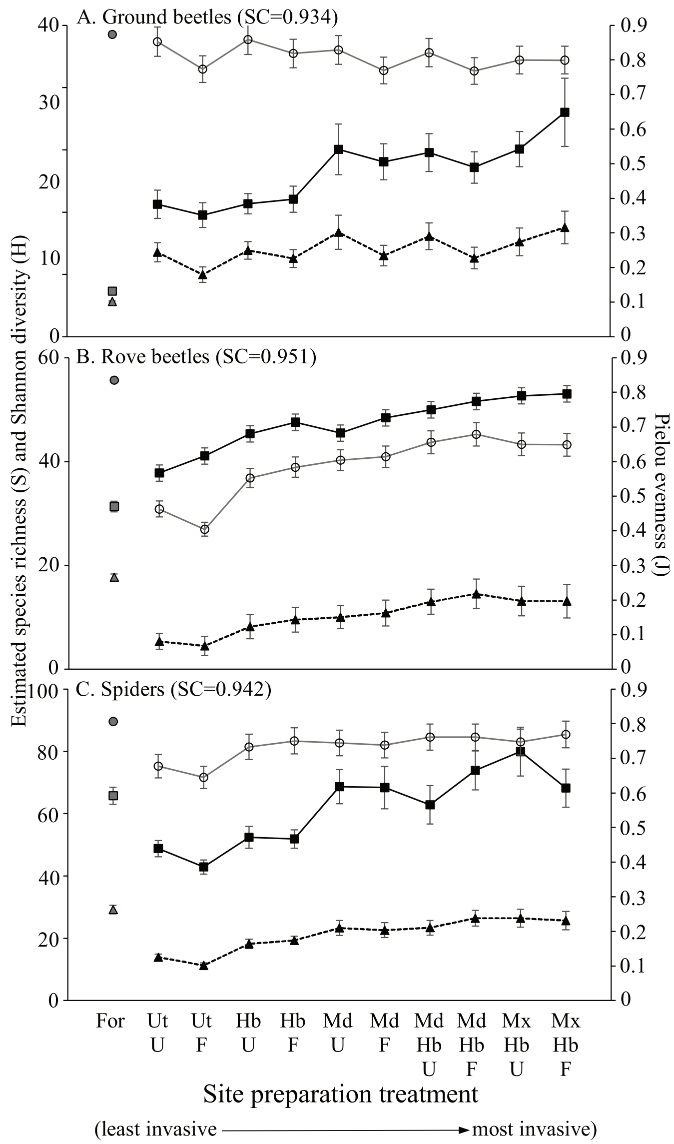
There was a total of 216 epigaeic spider species collected during this study, of which 117 species were collected in the forest stands, 177 species collected in the reclaimed areas, and 78 species collected in both the forest stands and borrow pits (Appendix Table A1). In the pooled sample of spiders, there was a total of 45 singletons, 16 doubletons, and three species with catches of greater than 5% of the total (*Pardosa moesta* Banks, *Cybaeopsis euopla* (Bishop & Crosby), and *Alopecosa aculeata* (Clerck)), with *P. moesta* making up over 25% of the catch (Appendix Table A1).

Spider assemblages tended to respond to increasing reclamation treatment efforts in a similar way to rove beetle assemblages. At a sample coverage of 94.2%, spider species richness and diversity increased with increasing treatment invasiveness (Fig. 4C). Spider species richness was lowest in the untreated and herbicide-treated plots and highest in the forest and soil disturbed plots (Fig. 4C). Spider species diversity was highest in the forest stands, and gradually increased with the intensity of treatment (Fig. 4C). Spider assemblage evenness was highest in the forest stands and lowest in the untreated borrow pit plots (Fig. 4C).

Arthropod assemblage patterns

All three taxa showed similar patterns of faunal similarity among forest sites and reclaimed treatments in a cluster analysis (Fig. 5). The forest assemblages were somewhat unique being only 4% (ground beetles), 10% (rove beetles), and 14% (spiders) similar to the fauna of the reclaimed areas

Fig. 4. Coverage-based rarefaction estimated species richness (black squares), Shannon diversity (black triangles), and Pielou evenness (open circles) of (A) ground beetle, (B) rove beetle, and (C) spider assemblages collected by pitfall traps in different silvicultural site preparation treatments of reclaimed borrow pits near Cold Lake, Alberta. Error bars represent the 95% confidence level, and non-overlapping error bars are considered significant at $\alpha = 0.05$. Treatments: Ut = untreated; Hb = herbicide; Md = mounding; U = unfertilized; F = fertilized; For = adjacent undisturbed forest blocks.



(Fig. 5). For all three taxa, the fauna collected from the untreated and herbicide treatments grouped together as most similar (Fig. 5), ranging in similarity from 67% to 74% to the fauna of the soil disturbed treatments. For both rove beetles and spiders, the fauna from the mounding treatment grouped together with the mounding + herbicide treatment, with the mixing + herbicide treatment the most different (Fig. 5); whereas the ground beetles collected in soil disturbed plots did not show a clear pattern (Fig. 5). The silvicultural treatments seemed to have a larger effect than the

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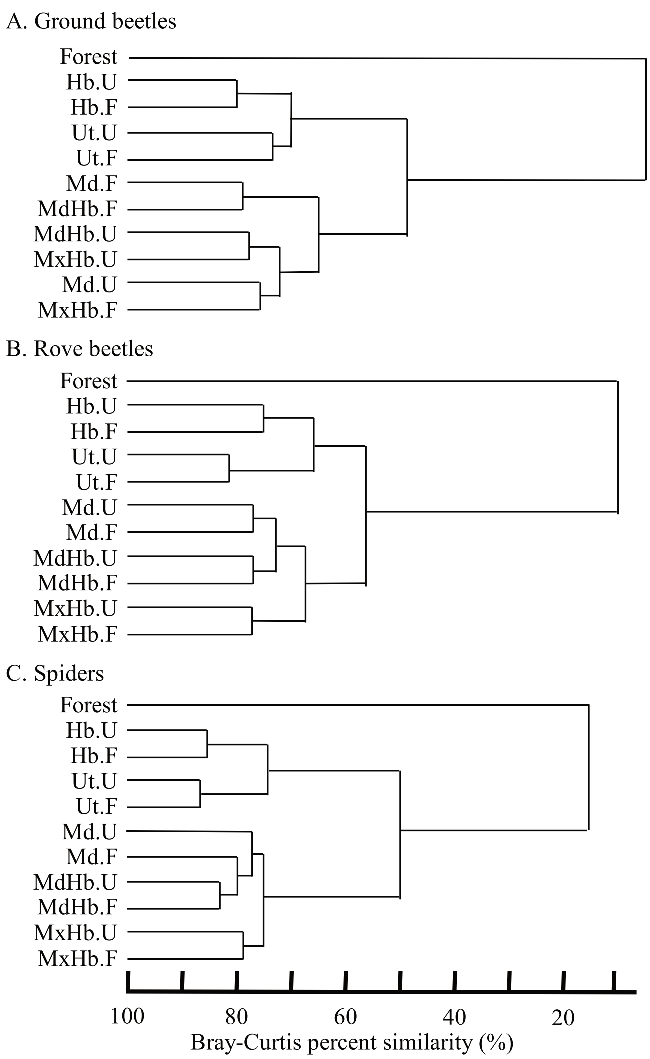
Fig. 5. Similarity of (A) ground beetle, (B) rove beetle, and (C) spider catches collected with pitfall traps in 1-year post reclaimed sites using different site preparation methods and in adjacent undisturbed forest stands near Cold Lake, Alberta. Treatment abbreviations: Ut = untreated; Hb = herbicide; Md = mounding; MdHb = mounding + herbicide; and MxHb = mixing + herbicide; F = fertilized; U = unfertilized.



application of fertilizer, as rove beetle and spider faunas from the fertilized and unfertilized treatments tended to group together as more similar to each other than other silvicultural treatments (Fig. 5).

Arthropod responses to silvicultural treatment and environmental variables

RDA analyses were conducted to quantify the amount of variation in each taxon assemblage within the reclamation areas by the explanatory variables (site, silvicultural treatment, and treatment + fertilization) and by the 12 environmental variables (Appendix Table A2). The RDA models for the explanatory variables were statistically significant accounting for 14%–22% of the constrained variance for each taxon (Table 1A). Site (borrow pit) and silvicultural treatment were significant for all three taxa but not fertilization (Table 1A). For each taxon, the first two RDA axes were significant, with axis 1 explaining 61%–76% of the constrained variance and axis 2 explaining for 20%–33% of the constrained variance (Table 1A).

The RDA models for the environmental variables were also statistically significant (Table 1B). The conditional variable site (borrow pit) explained 11%–27% of the variance, and the environmental variables explained 13%–18% of the constrained variance for each taxon (Table 1B). The first RDA axis for all three taxa explained 34.9%–52.4% of the constrained variance (Table 1B) and separated the arthropod faunas of the untreated and herbicide treatments on the right of the ordinate and the soil disturbance treatments on the left of the ordinate (Fig. 6). The second RDA axis for all three taxa explained 13.4%–18.9% of the constrained variance (Table 1B) and separated the arthropod faunas of the mounding treatment from the mounding + herbicide and mixing + herbicide treatments (Fig. 6). Organic matter depth, total plant cover, and forb cover were identified as statistically significant variables influencing the distribution of all three taxa (Fig. 6). In addition, PAR was also identified as influencing ground beetle assemblages, the amount of bare soil and sedge cover influenced rove beetle assemblages, and the amount of bare soil and soil temperature influenced spider assemblages (Fig. 6).

A total of 61 epigaeic arthropod species had indicator values of >0.80 and were significant at $\alpha = 0.05$ (Table 2). The vast majority of these species, eight ground beetles, 20 rove beetles, and 27 spiders, were indicators of the adjacent undisturbed forest (Table 2). Two spider species, *Pardosa moesta* Banks and *Xysticus ferox* (Hentz) were indicators of the reclaimed areas; three species *Agonum cupreum* Dejean, *Quedius fulvicollis* (Stephens), and *Xysticus ellipticus* Turnbull, Dondale & Redner were indicators primarily of the silvicultural treatments with undisturbed soils; and *Poecilus lucublandus* (Say) was identified as an indicator of highly disturbed soils in the reclamation treatment areas (Table 2).

Discussion

Environmental differences among site preparation treatments

Forest sites differed significantly from the borrow pits (Fig. 2) not only by the presence of overstory trees but also by the amount of organic material in the soil and the presence of shrubs. In general, the forest floor soils were cooler with less light penetration to the surface than in the open borrow pits. Although litter formed a significant layer in the herbicide-treated plots, the main contribution to this litter was from dead grass and weedy forb stems, whereas in the forest litter is almost exclusively formed by dead leaves and woody material. The leaf litter layer not only acts as a significant nutrient source for forest soils (Jacob et al. 2009) and as a substrate for fungi and other microorganisms (Purahong et al. 2016) but also creates the complex forest floor structure that epigaeic arthropods exploit (Koivula et al. 1999). Leaf litter also acts as an insulator that helps control forest soil moisture and temperature levels (Park et al. 1998; Sayer 2007).

Table 1. Redundancy analysis diagnostics for each taxon collected in the reclaimed sites. (A) Using explanatory variables (site, treatment, and fertilization) to explain different components of faunal variation; and (B) using the 12 environmental variables (Appendix Table A2) to explain faunal variation with the site as a conditional (blocking) variable.

Taxon	*F*-test	*P*-value	Constrained variance	Axis 1	Axis 2	Significant factors
A. Explanatory variables						
Ground beetles	$F_{[3,116]} = 6.19$	0.001	0.14	61.1	33.3	Site: $F_{[1,116]} = 7.15$, $P = 0.001$; Treatment: $F_{[1,116]} = 10.28$, $P = 0.001$
Rove beetles	$F_{[3,116]} = 10.64$	0.001	0.22	75.6	20.3	Site: $F_{[1,116]} = 24.13$, $P = 0.001$; Treatment: $F_{[1,116]} = 6.48$, $P = 0.001$
Spiders	$F_{[3,116]} = 9.94$	0.001	0.20	67.7	29.2	Site: $F_{[1,116]} = 19.98$, $P = 0.001$; Treatment: $F_{[1,116]} = 8.86$, $P = 0.001$

Taxon	*F*-test	*P*-value	Conditioned variance	Constrained variance	Axis 1	Axis 2
B. Environmental variables						
Ground beetles	$F_{[12,105]} = 2.27$	0.001	0.11	0.18	52.4	15.6
Rove beetles	$F_{[12,105]} = 1.93$	0.001	0.27	0.13	34.9	18.9
Spiders	$F_{[12,105]} = 2.02$	0.001	0.21	0.15	46	13.4

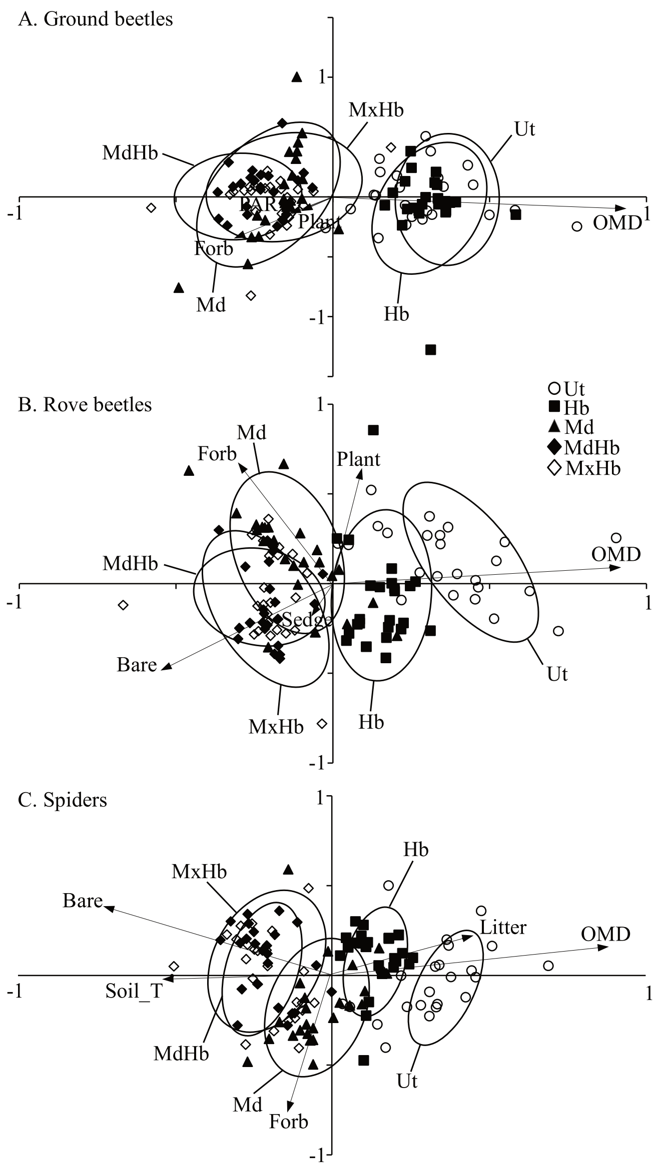
Silvicultural treatments within the borrow pits tended to group together based on environmental characteristics: untreated plots, Hb plots, Md plots, and MdHb + MxHb plots (Fig. 2). Application of herbicide not only created high levels of grass and weed litter, but also retarded establishment of vegetation in treatments treated with herbicide, average plant cover was 8.4%, 42.3%, and 50.7%, respectively, in the Hb, MdHb, and MxHb plots as compared to 85.1% and 87.6%, respectively, in the Md and untreated plots that did not receive herbicide (Appendix Table A2). These differences also reflected the abiotic conditions, as treatments with higher vegetation cover also had relatively lower soil temperatures and light penetration. These effects may influence the future growth of the planted seedlings in the MdHb and MxHb treatments as lower plant competition will likely give seedlings an advantage during establishment. In addition, soil disturbance in the mounded and mixed treatments helped to break up the highly compacted soil which may enhance root propagation and help mix available organic material into the mineral soil (Fernández et al. 2017, 2019). Thus long-term monitoring of these plots will be required to track the trajectory of vegetation recovery at these sites.

Arthropod composition among forest and borrow pits

The epigaeic arthropods comprised two distinct groups, species associated with the forest blocks and species associated with the grassland habitat of the borrow pits (Fig. 5). Only 37% of the species collected were found in both the forests and borrow pits. This is not surprising as many studies have shown that epigaeic arthropods exist in distinct communities extending from the interior forest, across the forest edge, to open habitats such as grasslands (e.g., Spence et al. 1996; Downie et al. 1996; Kotze and Samways 1999; Magura et al. 2001; Niemelä et al. 2006; Bieringer et al. 2013; Lacasella et al. 2015; Hu et al. 2022). For instance, five ground beetle, nine rove beetle, and 18 spider species appear to be forest specialists at these sites and have been associated with forest stands in other studies in Alberta (Spence et al. 1997; Buddle and Draney 2004; Work et al. 2004; Pinzon et al. 2011, 2012; Hammond et al. 2018, 2021). Species that were identified as significant indicators of the forest stands such as *Agonum retractum* LeConte, *Carabus chamissonis* Fischer von Waldheim, *Platynus decentis* (Say), *Lordithon fungicola* Campbell, *Quedius rusticus* Smetana, *Q. velox* Smetana, *Tachinus frigidus* Erichson, *T. fumipennis* (Say), *T. quebecensis* Robert, *Allomengea dentisetis* Grube, *Bathyphantes pallidus* (Banks), *Microneta viaria* (Blackwall), *Sissicottis montanus* (Emerton), *Walckenaeria directa* (O. Pickard-Cambridge), *Pardosa mackenziana* (Keyserling), *Euryopsis argentea* Emerton, *Xysticus luctuosus* (Blackwall), and *X. obscurus* Collett (Table 2) may have reduced dispersal capabilities and (or) require habitat or microhabitat characteristics found in forest stands. Such species should be good indicators of forest recovery following reclamation.

The species found associated with borrow pits fall into two categories, either true grassland species or species known to colonize recently disturbed areas. A total of 16 ground beetle, 28 rove beetle, and 30 spider species were collected almost exclusively from the borrow pits (Appendix Table A1); however, only five species were identified as significant indicators of borrow pits with an indicator value >0.80 (Table 2). For example, the ground beetles *Poecilus lucublandus* (Say) and *Agonum cupreum* Dejean are known to favour areas of human activity and are good colonizers, dispersing by flight and feeding on lepidopterous and dipterous eggs, caterpillars, grubs, and pupae common in open habitats (Larochelle and Larivière 2003). Relatively little is known about the life habits of many rove beetles; however, genera such as *Gabrius*, *Gyrohypnus*, and *Neohypnus* belong to the subfamily Staphylininae and are good fliers and are generalist predators on medium to small arthropods (Smetana 1982, 1995). Many families of spiders include species that primarily occupy open habitats such as grasslands. The wolf spider *Pardosa moesta*, for example, is a common spider found in cutblocks and managed forests in Alberta (Pinzon et al. 2011, 2012) but is also found

Fig. 6. Redundancy analysis of Hellinger transformed standardized abundance of the arthropod fauna partitioned by site preparation treatment. (A) Ground beetles; (B) rove beetles; (C) spiders. Ellipses represent the centroid of the 95% confidence interval for treatments. Sites were used as a conditional variable. Treatment abbreviations: Ut = untreated; Hb = herbicide; Md = mounding; MdHb = mounding + herbicide; and MxHb = mixing + herbicide. Environmental variables include: PAR =light; Soil_T = soil temperature; OMD = organic matter depth; Bare = bare soil; Litter = total litter cover; Plant = total plant cover; Forb = forb cover; Sedge = sedge cover.



in large numbers in meadows, hayfields, bogs, and urban lawns where they actively hunt prey using keen vision, speed, and power to capture other small ground-dwelling invertebrates (Dondale and Redner 1990). The species *Argenna obesa* Emerton belongs to the family Dictynidae, which includes small, rather sedentary spiders that weave irregular mesh-like webs near ground level and disperse widely via ballooning (Chamberlin and Gertsch 1958). The Thomisidae, or crab spiders, were represented in borrow pits by large numbers of *X. ellipticus* Turnbull, Dondale & Redner, *X. emertoni* Keyserling, and *X. ferox* Hentz. These dull brown spiders blend in with grass litter in open fields, where they sit and wait for predators (Dondale and Redner 1978). Many species of Linyphiidae were also found primarily in the borrow pit, and one example, *Mermessus trilobatus* (Emerton) is a small, eurytopic species, that balloons and is known to be a pioneer in disturbed habitats (Millidge 1987; Hirna 2017). In short, the species commonly collected in borrow pits are generally good dispersers and tolerant of a variety of environmental conditions. The beetles tend to have smaller body sizes and are macropterous or good runners, whereas the spiders, which tend to disperse by ballooning as small juveniles, tend to have larger adult body sizes and are active hunters (Pedley and Dolman 2014; Hammond et al. 2018).

Arthropod catch and diversity among silvicultural treatments in the reclaimed borrow pits

During the first year following silvicultural treatments in the borrow pits the epigaeic species fauna fell into two broad categories: species tolerant of highly disturbed soil and those found mainly in the untreated and Hb treatment plots. However, our three model taxa seemed to respond differently. Catches of ground beetles were mostly unaffected by treatment; however, species richness increased and evenness decreased slightly with increasing invasiveness of treatment (Figs. 3 and 4). All silvicultural treatments retained species that had high relative abundance in untreated plots, although the identity of those species differed between the undisturbed and disturbed soil treatments (Supplementary Fig. S1). *Agonum cupreum*, for example, was found in relatively high abundance in the undisturbed and herbicide treated plots; whereas *P. lucublandus* and *A. obesa* dominated the catches from treatments with soil disturbance, comprising 16%–25% and 13%–26% of the fauna, respectively (Appendix Table A1). This contrasts with results from agricultural systems in Alberta, where catches of ground beetles significantly increased despite decreases in diversity and evenness in more highly tilled areas (Cárcamo 1995; Cárcamo et al. 1995). This result may reflect the location and site history of the agricultural areas which were in aspen parkland areas within a matrix of agricultural land, whereas our study was located in a boreal mixedwood forest. Our findings agreed with other studies of ground beetle diversity in forests where species diversity is often dependent upon site locations and specific forest type as well as the severity of soil disturbance (Beaudry et al. 1997; Pearce and Venier 2006; Sklodowski 2017; Hartshorn 2021).

Rove beetles and spiders responded differently than ground beetles. Catches were significantly lower, and richness, diversity, and evenness were significantly higher with level of soil disturbance (Figs. 3 and 4). In contrast to the data for ground beetles, as the level of soil disturbance increased not only did overall abundance of rove beetles and spiders

Table 2. Epigaeic arthropod taxa identified as significant indicators with an indicator value >0.80 of different reclamation site treatments identified by cluster analysis and RDA.

Taxon	Species	Treatment[†]	IndVal	Adjusted *P*-value
Ground beetles	*Platynus decentis* (Say)	Forest	0.990	0.014
Ground beetles	*Agonum retractum* LeConte	Forest	0.990	0.014
Ground beetles	*Pterostichus adstrictus* Eschscholtz	Forest	0.990	0.014
Ground beetles	*Calathus ingratus* Dejean	Forest	0.963	0.014
Ground beetles	*Stereocerus haematopus* (Dejean)	Forest	0.912	0.014
Ground beetles	*Carabus chamissonis* Fischer von Waldheim	Forest	0.906	0.014
Ground beetles	*Pterostichus pensylvanicus* LeConte	Forest	0.878	0.014
Ground beetles	*Synuchus impunctatus* (Say)	Forest	0.850	0.014
Ground beetles	*Poecilus lucublandus* (Say)	Md, MdHb, MxHb	0.884	0.014
Ground beetles	*Agonum cupreum* Dejean	Ut, Hb, MxHb	0.849	0.014
Rove beetles	*Tachinus fumipennis* (Say)	Forest	1.000	0.022
Rove beetles	*Tachinus frigidus* Erichson	Forest	0.999	0.022
Rove beetles	*Quedius rusticus* Smetana	Forest	0.999	0.022
Rove beetles	*Lordithon fungicola* Campbell	Forest	0.999	0.022
Rove beetles	*Tachinus quebecensis* Robert	Forest	0.999	0.022
Rove beetles	*Quedius uteanus uteanus* (Casey)	Forest	0.997	0.022
Rove beetles	*Dinothenarus pleuralis* (LeConte)	Forest	0.994	0.022
Rove beetles	*Tachinus elongatus* Gyllenhal	Forest	0.993	0.022
Rove beetles	*Quedius labradorensis labradorensis* Smetana	Forest	0.987	0.022
Rove beetles	*Bolitobius sp.*	Forest	0.983	0.022
Rove beetles	*Acidota quadrata* (Zetterstedt)	Forest	0.979	0.022
Rove beetles	*Gabrius brevipennis* (Horn)	Forest	0.962	0.022
Rove beetles	*Lathrobium washingtoni* Casey	Forest	0.958	0.022
Rove beetles	*Stenus austini* Casey	Forest	0.949	0.022
Rove beetles	*Ischnosoma splendidum* (Gravenhorst)	Forest	0.925	0.022
Rove beetles	*Quedius velox* Smetana	Forest	0.913	0.022
Rove beetles	*Quedius frigidus* Smetana	Forest	0.857	0.022
Rove beetles	*Quedius brunnipennis* Mannerheim	Forest	0.816	0.022
Rove beetles	*Tachinus basalis* Erichson	Forest	0.816	0.022
Rove beetles	*Pseudopsis sagitta* Herman	Forest	0.811	0.022
Rove beetles	*Quedius fulvicollis* (Stephens)	Forest, Ut, Hb	0.845	0.022
Spiders	*Allomengea dentisetis* (Grube)	Forest	0.996	0.041
Spiders	*Bathyphantes pallidus* (Banks)	Forest	0.995	0.041
Spiders	*Pardosa mackenziana* (Keyserling)	Forest	0.993	0.041
Spiders	*Walckenaeria directa* (O. Pickard-Cambridge)	Forest	0.992	0.041
Spiders	*Agroeca ornata* Banks	Forest	0.988	0.041
Spiders	*Amaurobius borealis* Emerton	Forest	0.985	0.041
Spiders	*Lepthyphantes intricatus* (Emerton)	Forest	0.973	0.041
Spiders	*Pocadicnemis americana* Millidge	Forest	0.962	0.041
Spiders	*Euryopis argentea* Emerton	Forest	0.913	0.041
Spiders	*Lepthyphantes alpinus* (Emerton)	Forest	0.913	0.041
Spiders	*Oreonetides vaginatus* (Thorell)	Forest	0.913	0.041
Spiders	*Pityohyphantes subarcticus* Chamberlin & Ivie	Forest	0.913	0.041
Spiders	*Sisicottus montanus* (Emerton)	Forest	0.913	0.041
Spiders	*Pardosa uintana* Gertsch	Forest	0.904	0.041
Spiders	*Xysticus canadensis* Gertsch	Forest	0.904	0.041
Spiders	*Xysticus luctuosus* (Blackwall)	Forest	0.902	0.041
Spiders	*Microneta* viaria (Blackwall)	Forest	0.902	0.041
Spiders	*Sciastes truncatus* (Emerton)	Forest	0.899	0.041
Spiders	*Neon nelli* (G.W. Peckham & E.G. Peckham)	Forest	0.888	0.041
Spiders	*Diplocentria bidentata* (Emerton)	Forest	0.826	0.041
Spiders	*Arctobius agelenoides* (Emerton)	Forest	0.816	0.041

Table 2. (*concluded*).

Taxon	Species	Treatment†	IndVal	Adjusted *P*-value
Spiders	*Clubiona canadensis* Emerton	Forest	0.816	0.041
Spiders	*Diplocentria rectangulata* (Emerton)	Forest	0.816	0.041
Spiders	*Improphantes complicatus* (Emerton)	Forest	0.816	0.041
Spiders	*Sisis rotundus* (Emerton)	Forest	0.816	0.041
Spiders	*Xysticus obscurus* Collett	Forest	0.816	0.041
Spiders	*Agelenopsis utahana* (Chamberlin & Ivie)	Forest	0.802	0.041
Spiders	*Pardosa moesta* Banks	Ut, Hb, Md, MdHb, MxHb	0.996	0.041
Spiders	*Xysticus ferox* (Hentz)	Ut, Hb, Md, MdHb, MxHb	0.944	0.041
Spiders	*Xysticus ellipticus* Turnbull, Dondale & Redner	Ut, Hb, Md	0.880	0.041

†Ut = untreated, Hb = herbicide, Md = mounding, MdHb = mounding + herbicide, MxHb = mixing + herbicide.

decrease but representation by highly abundant species also decreased (Supplementary Fig. S1). The result was a shift from at least some species with high abundance to an assemblage of species with relatively low abundance (<5 individuals). Although much is known about the responses of rove beetles to forest disturbances such as forest harvesting practices (Pohl et al. 2008), relatively little is known about their responses to soil disturbance. In general, however, rove beetle diversity and catch decreases with increasing soil disturbance (Krooss and Schaefer 1998; Nagy et al. 2015; Méndez-Rojas et al. 2021). Although both spider diversity and evenness increased, overall numbers collected decreased with soil disturbance. This contrasts to results from other agricultural and forestry settings showing that both spider numbers and diversity increased with disturbance (Rypstra et al. 1999; Pearce et al. 2004; Topa et al. 2021). However, such increases may often come with decreases in forest specialists (Pinzon et al. 2011, 2012, 2016).

Fertilizing the plots had little to no effect on the epigaeic fauna as has also been reported in other agro-systems (Miñarro et al. 2009). This is not surprising in our study for several reasons. First, the purpose of the fertilizer tablets was to provide nutrients directly to the soil near planted seedlings. Fertilizer was not broadcast spread throughout the entire plot, and most likely the fertilizer had only localized effects within the plots. Second, the tablets were developed for slow release and it is unlikely that concentrations of fertilizer at any given time were high. Third, any effects of fertilization on epigaeic arthropods would be expressed indirectly in the longer term (Sloan and Jacobs 2013) through changes in the microenvironment of the plots through increased growth of the trees, increased leaf litter, higher organic matter input, and increasing soil structure (Pfiffner and Niggli 1996; Brown and van den Driessche 2005; DesRochers et al. 2006; Sloan and Jacobs 2013). Thus, once again, we argue that long-term monitoring is essential to fully understand potential impacts of the silvicultural treatments.

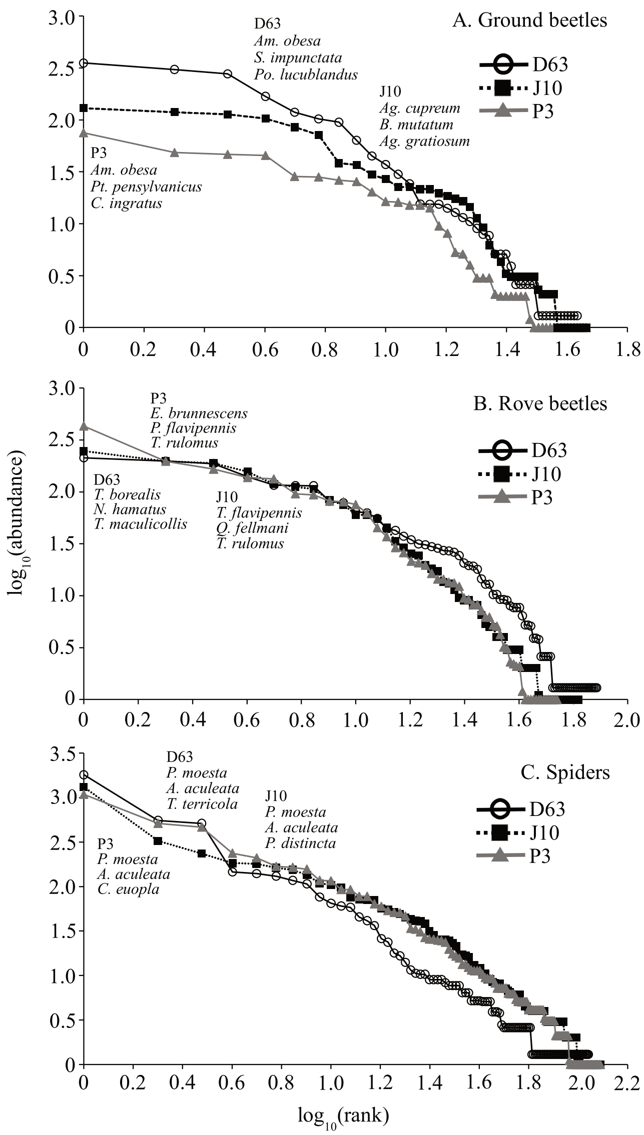
Variation in the epigaeic fauna among individual borrow pits and responses to environmental variables

Redundancy analysis demonstrated that each of the model taxa was influenced both by the individual borrow pits and by environmental factors associated with the treatments. Ground beetles seemed to be the most influenced by an individual site. For example, the dominant ground beetle species differed among the three borrow pits, as did the carabid rank-abundance distribution (i.e., each borrow pit differed in dominance structure; Fig. 7A). The rank-abundance of rove beetles was reasonably similar among sites; however, the dominant species were different, even though the body sizes among each of the different taxa were similar among the sites (Fig. 7B). Spiders responded least to the sites, with the two dominant spider species and species rank-abundance distribution nearly the same among all of the sites (Fig. 7C).

It has been shown that, at least for ground beetles, different community assembly rules apply for forest and grassland species. For example, ground beetles colonizing grasslands showed a random assembly process, whereas co-occurring beetle species along the edges and in the forest interior were similar in functional and phylogenetic relatedness (Magura and Lövei 2019). This suggests that colonization of disturbed grasslands by epigaeic beetles is a random process dependent upon the competitive abilities of individual species, whereas species in the forest are determined primarily by environmental filters (Magura and Lövei 2019). Also, ground beetle species typical of interior forest are better adapted to cross the edge into open habitats, whereas open-habitat specialists with high dispersal power seemed not to be able to penetrate into the forest interior (Magura and Lövei 2020). It is not known whether these colonization strategies hold true for other invertebrate taxa such as the rove beetles and spiders. Although each of these borrow pits was originally reclaimed 25–30 years ago, little information is available as to specific previous land use history. Differences in the sites with respect to overstorey cover, age, ecological classification related to moisture and nutrient regime, and previous management history might all, or in part, influence colonization of these areas by arthropods.

All three model taxa also responded to measured environmental variables such as depth of organic matter and other soil and plant characteristics (Fig. 6). It seems that such biotic and structural components of the sites more directly influenced arthropod responses than did abiotic factors such as light penetration and temperature. Although abiotic environmental variables had a significant influence on epigaeic

Fig. 7. Rank abundance plots for (A) ground beetles, (B) rove beetles, and (C) spiders collected with pitfall traps 1-year post reclamation. For each borrow pit, the three most collected species for each taxon are listed in descending order of abundance.



arthropod faunas when analysed at coarser spatial scales (Hammond et al. 2021), such effects are often synergistic with biotic structural characteristics operating at finer spatial scales (Hammond et al. 2018, 2021). For example, when the tree canopy and other understory elements are removed solar radiation and wind flow through the site increase, resulting in greater temperature fluctuations and moisture levels of the soil (Pearce and Venier 2006). Soil disturbance can result in the formation of different microhabitats. It is understood, for example, that litter type and depth influence the amount and type of foraging niches available to both macro- and microinvertbrates (Battigelli et al. 2004; Berch et al. 2007) and also influence vulnerability to predators and desiccation (Pearce et al. 2003; Hammond et al. 2018). Attachment sites for web building are an important structural feature needed for many spiders and are greatly influenced by soil disturbance (Pearce et al. 2004; Diehl et al. 2013). Finally, the presence and volume of coarse woody material have been intimately linked to the abundance and diversity of epigaeic faunas in forests, as it provides necessary soil structure and hiding places for beetles and spiders (Pearce and Venier 2006). All of these factors taken together with particular histories of colonization influence local species composition, abundance, and diversity, and such variation likely underlies the differences observed between borrow pits.

Conclusions

Over the last four decades, much research has gone into understanding the biotic and abiotic processes that characterize healthy functional forests and their responses to disturbance, in particular those of anthropogenic origin. Clearly, reclaiming post disturbance sites and restoring them back to a state approximating natural conditions is a daunting task, especially if previous reclamation attempts have failed, or little is known about the site history. Drever et al. (2006) suggested that ecosystem recovery is a function of pre-disturbance conditions, intensity and frequency of disturbances, and measures taken that may alter the successional dynamics of a given site. It is difficult to determine which site preparation methods will be successful and to predict reclamation outcomes even though it is required by law to show successful reclamation trajectories as soon as possible on industrial landscapes where multiple and intensive site disturbances have occurred.

The soil structure, total plant cover, and amount of organic matter in the soil play significant roles in the reestablishment of arthropod communities at disturbed sites. Further, soil compaction, reduced organic matter, and cover of noxious weeds greatly influence the recovery trajectories of reclaimed sites (Mackenzie and Naeth 2010; Pinno et al. 2012; Errington and Pinno 2016; Hammond et al. 2018). Amendment of soils with different types of organic matter can increase soil nutrients, change soil moisture levels, and improve the growth of planted seedlings (Stuckey and Hudak 2001; Larchevêque et al. 2006; Somerville et al. 2018, 2019). In particular, wood chips that may be present in great quantities during the initial phases of site construction provide an effective onsite soil amendment. Both as a mulch and in whole form, wood chips contribute nutrients to the soil, increase soil structure, help to control weeds, and increase the biodiversity of reclaimed sites (Bulmer 2000; Homyak et al. 2008; Scharenbroch and Watson 2014; Klimek at al. 2020). In some types of soil, however, additional nitrogen fertilization may be required to counter nitrogen immobilization that may occur depending on wood chip size and species (e.g., Venner et al. 2011). Future work about what types and amounts of organic material amendment will best enhance seedling establishment and promote the movement of forest species back on to reclaimed sites would be useful.

Even on an industrial landscape where the forest has been highly fragmented, forest remnants retain forest specialist species that eventually may re-colonize treated areas if habitat conditions are suitable following reclamation. We have shown that reclamation practices can have direct effects on the abundance, diversity, and composition of the epigaeic fauna. Long-term monitoring of these sites is necessary to understand the trajectories of tree growth, understorey recovery, and future arthropod colonization. For example, it may require years for fertilization to promote enhanced tree growth that leads to increases in soil organic matter, leaf litter, and soil structure, all of which are essential for the reestablishment of forest arthropod populations. In a forestry context, it takes approximately 30 years for arthropod communities typical of aspen forest to converge following wildfire and forest harvest (Buddle et al. 2000, 2006; Hammond et al. 2017). Our study provides the necessary baseline information which will be required to develop a longer-term perspective about the relative merits of reclamation practices considered in this study.

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Data availability

The data are stored with Natural Resources Canada, Canadian Forest Service, Northern Forestry Centre in Edmonton Alberta. The data can be accessed by contacting the lead author directly by email.

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Dustin J. Hartley is deceased.
We dedicate this article to our friend and colleague Dustin Joseph Hartley, a great beetle taxonomist who left us much too soon.

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Competing interests

There are no competing interests for any of the authors.

Supplementary material

Supplementary data are available with the article at https://doi.org/10.1139/cjfr-2022-0097.

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Appendix A

Appendix Tables A1 and A2 appear on the following pages.

Table A1. Epigaeic arthropod species collected using pitfall traps from undisturbed forest and three reclamation sites near Cold Lake, Alberta.

Group	Species	Abbrev.	Forest	Untreated		Herbicide		Mounding		Mounding + herbicide		Mixing + herbicide		Total
				Fertilized	Unfertilized	Fertilized	Unfertilized	Fertilized	Unfertilized	Fertilized	Unfertilized	Fertilized	Unfertilized	
Ground beetles (Carabidae)	*Agonoleptus conjunctus* (Say)	Agno_conj	0	0	0	0	0	0	0	1	0	0	1	2
Ground beetles (Carabidae)	*Agonum affine* Kirby	Agon_affi	1	0	0	0	0	0	0	0	0	0	0	1
Ground beetles (Carabidae)	*Agonum consimile* (Gyllenhal)	Agon_cons	1	0	0	0	0	0	0	0	0	0	0	1
Ground beetles (Carabidae)	*Agonum cupripenne* (Say)	Agon_cupp	0	0	0	0	0	0	0	0	0	0	1	1
Ground beetles (Carabidae)	*Agonum cupreum* Dejean	Agon_cupr	0	82	34	52	49	7	3	8	8	16	27	286
Ground beetles (Carabidae)	*Agonum gratiosum* (Mannerheim)	Agon_grat	2	18	40	10	9	15	9	7	11	11	8	140
Ground beetles (Carabidae)	*Agonum placidum* (Say)	Agon_plac	0	0	1	0	0	0	0	0	0	0	0	1
Ground beetles (Carabidae)	*Agonum retractum* LeConte	Agon_retr	693	2	0	2	1	1	0	0	2	2	1	704
Ground beetles (Carabidae)	*Amara aeneopolita* Casey	Amar_aeno	0	0	0	0	0	1	0	2	0	0	0	3
Ground beetles (Carabidae)	*Amara apricaria* (Paykull)	Amar_apri	0	0	0	0	0	0	0	0	3	0	0	3
Ground beetles (Carabidae)	*Amara cupreolata* Putzey	Amar_cupr	0	4	8	2	5	8	2	4	3	3	3	42
Ground beetles (Carabidae)	*Amara erratica* Dejean	Amar_erra	0	0	1	0	2	2	0	0	1	1	1	8
Ground beetles (Carabidae)	*Amara farcta* LeConte	Amar_farc	0	0	0	1	0	0	0	0	0	0	0	1
Ground beetles (Carabidae)	*Amara impuncticollis* Say	Amar_impu	0	2	2	2	6	8	11	7	8	1	5	52
Ground beetles (Carabidae)	*Amara latior* Kirby	Amar_lati	0	0	0	1	0	0	0	2	0	1	2	6
Ground beetles (Carabidae)	*Amara littoralis* Mannerheim	Amar_litt	0	3	5	4	6	4	1	6	7	2	4	42
Ground beetles (Carabidae)	*Amara lunicollis* Schiodte	Amar_luni	0	2	1	0	0	0	0	0	0	0	0	3
Ground beetles (Carabidae)	*Amara neoscotica* Casey	Amar_neos	0	13	18	7	11	6	6	9	6	3	5	84
Ground beetles (Carabidae)	*Amara obesa* Say	Amar_obes	0	6	22	52	33	99	32	76	35	38	36	429
Ground beetles (Carabidae)	*Amara sinuosa* Casey	Amar_sinu	0	0	0	0	0	1	2	2	1	0	1	7
Ground beetles (Carabidae)	*Amara torrida* (Panzer)	Amar_torr	0	2	3	5	9	16	2	5	5	5	3	55
Ground beetles (Carabidae)	*Badister obtusus* LeConte	Badi_obtu	3	0	0	0	2	1	1	0	2	1	0	10
Ground beetles (Carabidae)	*Bembidion canadianum* Casey	Bemb_cana	0	23	22	18	26	3	7	9	10	14	8	140
Ground beetles (Carabidae)	*Bembidion coloradense* Hayward	Bemb_colo	0	0	0	0	0	0	0	0	0	0	2	2
Ground beetles (Carabidae)	*Bembidion concolor* (Kirby)	Bemb_conc	0	0	0	0	0	0	0	0	1	0	0	1
Ground beetles (Carabidae)	*Bembidion quadrimaculatum dubitans* (LeConte)	Bemb_dubi	0	0	0	0	0	2	2	4	2	2	0	12
Ground beetles (Carabidae)	*Bembidion fortestriatum* (Motschulsky)	Bemb_fort	0	0	0	1	0	0	0	0	0	0	0	1
Ground beetles (Carabidae)	*Bembidion grapei* Gyllenhal	Bemb_grap	0	0	0	0	0	0	1	0	1	1	0	3
Ground beetles (Carabidae)	*Bembidion mutatum* Gemminger & Harold	Bemb_muta	0	0	1	1	0	16	6	21	19	4	6	74
Ground beetles (Carabidae)	*Bembidion quadrimaculatum oppositum* Say	Bemb_oppo	0	0	0	0	0	2	1	4	7	0	5	19
Ground beetles (Carabidae)	*Bembidion transversale* Dejean	Bemb_trans	0	1	0	0	0	0	0	0	0	0	0	1
Ground beetles (Carabidae)	*Bembidion versicolor* (LeConte)	Bemb_vers	0	0	0	0	1	2	0	1	0	1	6	11
Ground beetles (Carabidae)	*Blethisa catenaria* Brown	Blet_cate	0	0	0	0	0	0	0	0	1	0	0	1
Ground beetles (Carabidae)	*Bradycellus lugubris* (LeConte)	Brad_lugu	0	0	0	0	0	0	1	0	0	0	0	1
Ground beetles (Carabidae)	*Calathus ingratus* Dejean	Cala_ingr	608	43	46	23	17	18	16	7	13	15	2	808
Ground beetles (Carabidae)	*Calosoma frigidum* Kirby	Calo_frig	2	0	0	0	0	0	1	0	0	0	1	4

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Table A1. (*continued*).

Group	Species	Abbrev.	Forest	Untreated		Herbicide		Mounding		Mounding + herbicide		Mixing + herbicide		Total
				Fertilized	Unfertilized	Fertilized	Unfertilized	Fertilized	Unfertilized	Fertilized	Unfertilized	Fertilized	Unfertilized	
Ground beetles (Carabidae)	*Carabus chamissonis* Fischer von Waldheim	Cara_cham	79	0	0	1	0	2	2	0	0	0	0	84
Ground beetles (Carabidae)	*Carabus meander* Fischer von Waldheim	Cara_mean	0	4	6	2	9	1	3	2	3	2	5	37
Ground beetles (Carabidae)	*Carabus serratus* Say	Cara_serr	0	3	4	3	3	3	3	1	0	3	6	29
Ground beetles (Carabidae)	*Carabus taedatus agassii* LeConte	Cara_taed	8	4	1	5	6	0	1	1	2	1	2	31
Ground beetles (Carabidae)	*Chlaenius alternatus* Horn	Chla_alte	0	0	1	0	0	0	0	1	0	0	0	2
Ground beetles (Carabidae)	*Cicindela longilabrus longilabrus* Say	Cici_long	0	0	0	0	0	4	3	2	6	15	2	32
Ground beetles (Carabidae)	*Cymindis cribricollis* Dejean	Cymi_crib	11	0	0	0	0	1	1	0	1	1	0	15
Ground beetles (Carabidae)	*Dicheirotrichus cognatus* (Gyllenhal)	Dich_cogn	0	1	1	0	0	1	0	0	0	0	0	3
Ground beetles (Carabidae)	*Dyschirius politus politus* (Dejean)	Dysc_poli	1	0	0	0	0	0	0	0	0	0	0	1
Ground beetles (Carabidae)	*Dyschirius* spp. (*globulosus* + *longulus*)	Dysc_spp	1	2	3	9	2	2	1	4	2	6	5	37
Ground beetles (Carabidae)	*Elaphrus americanus* Dejean	Elap_amer	0	0	0	0	0	0	0	0	0	0	1	1
Ground beetles (Carabidae)	*Elaphrus clairvillei* Kirby	Elap_clai	1	0	2	0	3	0	0	0	0	1	0	7
Ground beetles (Carabidae)	*Harpalus ellipsis* LeConte	Harp_elli	0	0	0	0	1	0	0	0	0	0	0	1
Ground beetles (Carabidae)	*Harpalus fraternus* LeConte	Harp_frat	0	0	0	0	0	0	1	0	0	0	0	1
Ground beetles (Carabidae)	*Harpalus fulvilabris* Mannerheim	Harp_fulv	9	0	0	2	0	1	2	1	1	1	3	20
Ground beetles (Carabidae)	*Harpalus herbivagus* Say	Harp_herb	0	0	0	0	0	1	0	0	0	0	0	1
Ground beetles (Carabidae)	*Harpalus inocuus* LeConte	Harp_inoc	1	0	0	0	0	0	0	0	0	0	0	1
Ground beetles (Carabidae)	*Harpalus opacipennis* (Haldeman)	Harp_opac	1	2	2	6	4	7	2	4	4	4	2	38
Ground beetles (Carabidae)	*Harpalus somnulentus* Dejean	Harp_somn	0	0	1	0	0	5	0	2	2	0	2	12
Ground beetles (Carabidae)	*Loricera pilicornis pilicornis* (Fabricius)	Lori_pili	5	0	0	0	0	0	0	0	0	0	0	5
Ground beetles (Carabidae)	*Notiophilus aquaticus* (Linnaeus)	Noti_aqua	0	0	0	0	0	0	0	1	0	0	0	1
Ground beetles (Carabidae)	*Notiophilus borealis* Harris	Noti_bore	0	0	0	1	0	0	0	0	0	0	0	1
Ground beetles (Carabidae)	*Patrobus foveocollis* (Eschscholtz)	Patr_fove	8	0	0	0	0	0	0	1	1	1	0	11
Ground beetles (Carabidae)	*Patrobus longicornis* (Say)	Patr_long	0	0	0	0	0	0	0	0	0	1	0	1
Ground beetles (Carabidae)	*Patrobus stygicus* Chaudoir	Patr_styg	1	0	0	0	0	0	0	0	0	1	0	2
Ground beetles (Carabidae)	*Platynus decentis* (Say)	Plat_dece	1013	1	0	0	0	4	0	0	0	0	0	1018
Ground beetles (Carabidae)	*Platynus mannerheinii* (Dejean)	Plat_mann	2	0	0	0	0	0	0	0	0	0	0	2
Ground beetles (Carabidae)	*Poecilus lucublandus* (Say)	Poec_lucu	0	6	2	7	7	62	31	75	63	43	63	359
Ground beetles (Carabidae)	*Pterostichus adstrictus* Eschscholtz	Pter_adst	714	1	4	2	2	1	0	2	0	2	1	729
Ground beetles (Carabidae)	*Pterostichus femoralis* (Kirby)	Pter_femo	0	1	9	4	2	1	0	0	1	0	0	18
Ground beetles (Carabidae)	*Pterostichus pensylvanicus* LeConte	Pter_pens	169	49	31	52	34	8	10	10	6	12	9	390
Ground beetles (Carabidae)	*Pterostichus punctatissimus* (Randall)	Pter_punc	3	0	0	0	0	0	0	0	0	0	0	3
Ground beetles (Carabidae)	*Stereocerus haematopus* (Dejean)	Ster_haem	212	0	0	0	0	0	0	0	0	1	0	213

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Table A1. (*continued*).

Group	Species	Abbrev.	Forest	Untreated		Herbicide		Mounding		Mounding + herbicide		Mixing + herbicide		Total
				Fertilized	Unfertilized	Fertilized	Unfertilized	Fertilized	Unfertilized	Fertilized	Unfertilized	Fertilized	Unfertilized	
Ground beetles (Carabidae)	*Stenolophus fuliginosus* Dejean	Stlp_fuli	0	0	0	0	0	1	0	0	0	0	0	1
Ground beetles (Carabidae)	*Syntomus americanus* Dejean	Synt_amer	0	4	5	8	5	13	11	10	4	4	4	68
Ground beetles (Carabidae)	*Synuchus impunctatus* (Say)	Synu_impu	173	14	27	19	38	54	17	39	17	16	22	436
Ground beetles (Carabidae)	*Trechus apicalis* Motschulsky	Trec_apic	10	0	0	0	0	0	0	1	0	1	0	12
		Richness	27	26	29	29	27	38	32	35	35	37	35	73
		Catch	3732	293	303	302	293	384	192	332	259	237	255	6582
Rove beetles (Staphylinidae)	*Acidota crenata* (Fabricius)	Acid_cren	16	6	11	9	6	11	5	3	10	2	6	85
Rove beetles (Staphylinidae)	*Acidota quadrata* (Zetterstedt)	Acid_quad	186	7	2	5	8	3	2	4	1	2	0	220
Rove beetles (Staphylinidae)	*Acrolocha diffusa* (Fauvel)	Acro_diff	8	4	12	6	4	7	6	0	3	5	4	59
Rove beetles (Staphylinidae)	*Anotylus rugosus* (Fabricius)	Anot_rugu	0	0	0	0	0	0	0	0	0	1	0	1
Rove beetles (Staphylinidae)	*Anotylus sobrinus* (LeConte)	Anot_sobr	0	0	0	0	0	0	0	0	2	0	1	3
Rove beetles (Staphylinidae)	*Atrecus macrocephalus* (Nordmann)	Atre_macr	0	0	0	0	0	0	1	0	0	0	0	1
Rove beetles (Staphylinidae)	*Batrisodes spp.*	Batr_spp_	0	0	0	0	0	0	0	0	1	0	0	1
Rove beetles (Staphylinidae)	*Bisnius siegwaldii* (Mannerheim)	Bisn_sieg	0	0	0	0	0	1	0	0	0	0	0	1
Rove beetles (Staphylinidae)	*Bisnius tereus* Smetana	Bisn_tere	3	0	0	0	0	0	0	0	1	0	0	4
Rove beetles (Staphylinidae)	*Bledius spp.*	Bled_spp_	0	0	0	1	0	0	0	1	0	1	0	3
Rove beetles (Staphylinidae)	*Bolitobius analis* (Paykull)	Boli_anal	0	0	0	0	1	2	0	0	2	1	1	7
Rove beetles (Staphylinidae)	*Boltobius cingulatus* Mannerheim	Boli_cing	2	0	0	0	0	0	2	1	1	2	1	9
Rove beetles (Staphylinidae)	*Bolitobius sp.*	Boli_horn	25	1	0	0	1	0	0	1	0	1	0	29
Rove beetles (Staphylinidae)	*Bryoporus rufescens* LeConte	Bryo_rufe	0	3	2	2	4	0	2	1	3	2	0	19
Rove beetles (Staphylinidae)	*Carpelimus* spp.	Carl_spp_	0	0	0	8	2	2	17	1	7	5	1	43
Rove beetles (Staphylinidae)	*Dinothenarus capitatus* Bland	Dino_capi	2	0	0	0	0	0	0	0	0	0	0	2
Rove beetles (Staphylinidae)	*Dinothenarus pleuralis* (LeConte)	Dino_pleu	429	0	4	2	1	1	1	3	2	2	5	450
Rove beetles (Staphylinidae)	*Euaesthetus laeviusculus* Mannerheim	Euae_laev	0	5	18	13	22	0	0	0	1	1	19	79
Rove beetles (Staphylinidae)	*Euaesthetus spp.*	Euas_spp_	0	2	10	8	4	0	1	4	3	1	0	33
Rove beetles (Staphylinidae)	*Eucnecosum brunnescens* (Sahlberg)	Eucn_brun	33	74	145	48	86	13	54	42	33	23	30	581
Rove beetles (Staphylinidae)	*Eucnecosum tenue* (LeConte)	Eucn_tenu	1	5	11	1	1	0	4	0	2	2	1	28
Rove beetles (Staphylinidae)	*Eusphalerum pothos* (Mannerheim)	Eusp_poth	4	0	0	0	1	0	0	0	0	0	0	5
Rove beetles (Staphylinidae)	*Gabrius brevipennis* (Horn)	Gabr_brev	80	1	2	1	2	4	1	2	9	2	2	106
Rove beetles (Staphylinidae)	*Gabrius picipennis* (Maklin)	Gabr_pici	6	16	19	21	44	34	31	39	47	40	31	328
Rove beetles (Staphylinidae)	*Geodromicus* sp .	Geod_spA	0	0	1	0	1	1	0	0	0	0	0	3
Rove beetles (Staphylinidae)	*Gyrohypnus campbelli* Smetana	Gyro_camp	0	6	9	6	16	16	21	13	19	13	19	138
Rove beetles (Staphylinidae)	*Habrocerus schwarzi* Horn	Habr_schw	199	0	2	2	0	15	2	2	5	8	8	243
Rove beetles (Staphylinidae)	*Heterothops fusculus* LeConte	Hete_fusc	0	0	0	1	0	8	9	10	8	17	15	68
Rove beetles (Staphylinidae)	*Heterothops minor* Smetana	Hete_mino	0	0	0	0	1	2	0	1	2	1	1	8
Rove beetles (Staphylinidae)	*Ischnosoma fimbriatum* Campbell	Isch_fimb	8	0	1	2	1	5	4	1	2	2	1	27
Rove beetles (Staphylinidae)	*Ischnosoma pictum* (Horn)	Isch_pict	2	4	4	15	19	9	4	12	8	5	0	82
Rove beetles (Staphylinidae)	*Ischnosoma splendidum* (Gravenhorst)	Isch_sple	435	22	33	35	27	36	36	39	35	20	18	736

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Table A1. (*continued*).

Group	Species	Abbrev.	Forest	Untreated		Herbicide		Mounding		Mounding + herbicide		Mixing + herbicide		Total
				Fertilized	Unfertilized	Fertilized	Unfertilized	Fertilized	Unfertilized	Fertilized	Unfertilized	Fertilized	Unfertilized	
Rove beetles (Staphylinidae)	*Lathrobium fauveli* Duvivier	Lath_fauv	30	2	0	1	0	2	2	5	5	2	3	52
Rove beetles (Staphylinidae)	*Lathrobium fulvipenne* (Gravenhorst)	Lath_fulv	1	0	0	0	0	0	1	0	0	0	0	2
Rove beetles (Staphylinidae)	*Lathrobium* spA	Lath_nigr	0	0	0	0	0	0	1	0	0	0	0	1
Rove beetles (Staphylinidae)	*Lathrobium* spB	Lath_sp1	0	1	0	0	0	0	0	0	0	0	0	1
Rove beetles (Staphylinidae)	*Lathrobium washingtoni* Casey	Lath_wash	66	2	3	2	3	5	4	1	2	2	2	92
Rove beetles (Staphylinidae)	*Lordithon appalachianus* Campbell	Lord_appa	15	0	0	0	0	0	0	0	0	0	0	15
Rove beetles (Staphylinidae)	*Lordithon fungicola* Campbell	Lord_fung	132	0	0	0	0	0	0	1	0	0	0	133
Rove beetles (Staphylinidae)	*Mycetoporus americanus* Erichson	Myce_amer	6	0	0	0	0	0	0	1	0	0	1	8
Rove beetles (Staphylinidae)	*Mycetoporus bipunctatus* Campbell	Myce_bipu	0	0	0	2	1	0	1	2	0	0	0	6
Rove beetles (Staphylinidae)	*Mycetoporus inquisitus* Casey	Myce_inqu	3	7	4	9	0	2	3	1	2	2	1	34
Rove beetles (Staphylinidae)	*Mycetoporus* near *lucidulus*	Myce_luci	0	7	1	10	3	9	2	11	0	5	5	53
Rove beetles (Staphylinidae)	*Mycetoporus nigrans* Maklin	Myce_nigr	0	1	8	3	4	0	0	2	2	1	4	25
Rove beetles (Staphylinidae)	*Mycetoporus rufohumeralis* Campbell	Myce_rufo	0	0	0	0	0	0	1	0	0	0	0	1
Rove beetles (Staphylinidae)	*Mycetoporus rugosus* Hatch	Myce_rugo	6	10	14	29	17	23	22	16	12	8	8	165
Rove beetles (Staphylinidae)	*Mycetoporus triangulatus* Campbell	Myce_tria	0	0	0	1	0	0	0	0	0	0	0	1
Rove beetles (Staphylinidae)	*Neohypnus fragilis* (Casey)	Neoh_frag	0	0	0	0	0	0	0	1	0	0	0	1
Rove beetles (Staphylinidae)	*Neohypnus hamatus* (Say)	Neoh_hama	0	1	1	1	5	44	17	23	36	10	14	152
Rove beetles (Staphylinidae)	*Neohypnus obscurus* (Erichson)	Neoh_obsc	0	0	0	4	0	4	4	5	7	12	2	38
Rove beetles (Staphylinidae)	*Neohypnus* sp.	Neoh_spA_	0	0	0	0	0	1	0	0	0	0	0	1
Rove beetles (Staphylinidae)	*Nitidotachinus tachyporoides* (Horn)	Niti_tach	2	0	0	0	0	0	0	0	0	1	0	3
Rove beetles (Staphylinidae)	*Olophrum consimile* (Gyllenhal)	Olop_cons	5	7	8	6	8	11	8	0	5	3	9	70
Rove beetles (Staphylinidae)	*Olophrum rotundicolle* (Sahlberg)	Olop_rotu	3	12	4	4	7	1	1	0	1	0	3	36
Rove beetles (Staphylinidae)	Omalium spA.	Omal_sp2	1	0	0	0	0	0	0	0	0	0	0	1
Rove beetles (Staphylinidae)	Omalium spp.	Omal_spp_	2	0	0	0	0	1	0	1	0	0	0	4
Rove beetles (Staphylinidae)	*Ontholestes cingulatus* (Gravenhorst)	Onth_cing	14	1	0	0	1	1	0	1	1	1	0	20
Rove beetles (Staphylinidae)	*Orus dentiger* (LeConte)	Orus_dent	0	0	0	0	1	0	0	0	1	0	2	4
Rove beetles (Staphylinidae)	*Orus* spp.	Orus_spp_	0	0	0	0	0	0	0	0	1	0	0	1
Rove beetles (Staphylinidae)	*Oxytelus laqueatus* (Marsham)	Oxyt_laqu	1	0	0	0	0	0	0	0	0	0	0	1
Rove beetles (Staphylinidae)	*Pachystilicus hanhami* (Wickham)	Pach_hanh	0	0	0	0	0	1	0	0	0	0	0	1
Rove beetles (Staphylinidae)	*Paederus littorarius* Gravenhorst	Paed_litt	0	2	2	4	5	4	5	3	4	4	4	37
Rove beetles (Staphylinidae)	*Philonthus caeruleipennis caeruleipennis* (Mannerheim)	Phil_caer	12	0	0	0	0	0	0	0	0	0	0	12
Rove beetles (Staphylinidae)	*Philonthus concinnus* (Gravenhorst)	Phil_conc	0	1	0	1	0	0	0	0	0	0	2	4
Rove beetles (Staphylinidae)	*Philonthus flavibasis* Casey	Phil_flav	20	23	26	45	45	43	36	31	35	38	47	389
Rove beetles (Staphylinidae)	*Philonthus furvus* Nordmann	Phil_furv	0	0	0	1	0	0	0	0	0	0	1	2
Rove beetles (Staphylinidae)	*Philonthus varians* (Paykull)	Phil_vari	0	0	0	0	0	0	0	0	0	0	1	1
Rove beetles (Staphylinidae)	*Proteinus* spp.	Prot_spp_	2	0	0	0	0	1	0	0	0	0	0	3

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				Fertilized	Unfertilized	Fertilized	Unfertilized	Fertilized	Unfertilized	Fertilized	Unfertilized	Fertilized	Unfertilized	
Rove beetles (Staphylinidae)	*Pseudopsis sagitta* Herman	Pseu_sagi	16	0	0	0	0	1	0	0	0	0	0	17
Rove beetles (Staphylinidae)	*Pycnoglypta campbelli* Gusorov	Pycn_camp	0	6	2	2	0	0	0	0	1	0	0	11
Rove beetles (Staphylinidae)	*Quedius brunnipennis* Mannerheim	Qued_brun	71	0	0	0	0	0	0	0	0	0	0	71
Rove beetles (Staphylinidae)	*Quedius fellmani* (Zetterstedt)	Qued_fell	6	36	31	26	38	23	23	30	35	18	17	283
Rove beetles (Staphylinidae)	*Quedius frigidus* Smetana	Qued_frig	21	5	0	1	1	0	0	3	1	0	0	32
Rove beetles (Staphylinidae)	*Quedius fulvicollis* (Stephens)	Qued_fulv	63	36	67	14	21	14	20	9	10	5	7	266
Rove beetles (Staphylinidae)	*Quedius labradorensis labradorensis* Smetana	Qued_labr	130	1	1	0	1	4	1	3	0	1	2	144
Rove beetles (Staphylinidae)	*Quedius plagiatus* Mannerheim	Qued_plag	2	0	0	0	0	0	0	0	0	0	0	2
Rove beetles (Staphylinidae)	*Quedius rusticus* Smetana	Qued_rust	459	0	0	0	0	0	0	1	2	0	0	462
Rove beetles (Staphylinidae)	*Quedius simulator* Smetana	Qued_simu	23	1	2	0	2	1	0	0	0	0	0	29
Rove beetles (Staphylinidae)	*Quedius uteanus uteanus* (Casey)	Qued_utea	78	1	0	0	0	1	0	0	0	0	0	80
Rove beetles (Staphylinidae)	*Quedius velox* Smetana	Qued_velo	164	0	0	0	0	0	0	0	0	0	0	164
Rove beetles (Staphylinidae)	*Scaphium castanipes* Kirby	Scap_cast	1	0	0	0	0	0	0	0	0	0	0	1
Rove beetles (Staphylinidae)	*Sepedophilus littoreus* (Linnaeus)	Sepe_litt	0	0	0	1	0	0	0	0	0	0	0	1
Rove beetles (Staphylinidae)	*Stenus ageus* Casey	Sten_ageu	0	0	0	0	0	0	1	0	0	0	0	1
Rove beetles (Staphylinidae)	*Stenus angustus* Casey	Sten_angu	0	1	6	3	0	1	4	1	1	1	0	18
Rove beetles (Staphylinidae)	*Stenus assequens assequens* Rey	Sten_asse	0	4	4	1	1	0	1	0	1	0	0	12
Rove beetles (Staphylinidae)	*Stenus austini* Casey	Sten_aust	18	4	0	1	0	0	1	2	0	0	0	26
Rove beetles (Staphylinidae)	*Stenus canaliculatus* Gyllenhal	Sten_cana	0	0	0	0	0	0	0	0	0	1	0	1
Rove beetles (Staphylinidae)	*Stenus cariniceps* Maklin	Sten_cari	0	0	0	0	0	0	1	0	0	0	0	1
Rove beetles (Staphylinidae)	*Stenus egenus* Erichson	Sten_egen	0	2	2	0	0	0	0	0	0	1	0	5
Rove beetles (Staphylinidae)	*Stenus immarginatus* Maklin	Sten_imma	5	0	0	0	0	1	3	0	0	0	1	10
Rove beetles (Staphylinidae)	*Stenus juno* (Paykull)	Sten_juno	4	2	1	3	3	1	0	1	0	0	2	17
Rove beetles (Staphylinidae)	*Stenus laccophilus* Casey	Sten_lacc	0	0	0	0	0	0	0	0	0	0	1	1
Rove beetles (Staphylinidae)	*Stenus mammops mammops* Casey	Sten_mamm	10	21	35	23	22	29	27	13	18	13	14	225
Rove beetles (Staphylinidae)	*Stenus maritimus* Motschulsky	Sten_mari	1	1	0	0	0	0	0	0	0	0	0	2
Rove beetles (Staphylinidae)	*Stenus neglectus* Casey	Sten_negl	0	0	1	0	0	0	0	0	0	0	0	1
Rove beetles (Staphylinidae)	*Stenus pumilio* Erichson	Sten_pumi	0	0	0	0	0	0	0	0	0	0	1	1
Rove beetles (Staphylinidae)	*Stenus rossi* Sanderson	Sten_ross	0	0	0	0	0	0	0	0	0	0	1	1
Rove beetles (Staphylinidae)	*Stenus scrupeus* Casey	Sten_scru	0	0	0	0	1	0	0	0	0	0	0	1
Rove beetles (Staphylinidae)	*Stenus* spA	Sten_sp1	0	0	0	0	0	0	0	1	0	0	0	1
Rove beetles (Staphylinidae)	*Stenus* spp.	Sten_spp_	0	0	0	0	1	0	0	0	0	0	0	1
Rove beetles (Staphylinidae)	*Stenus stygicus* Say	Sten_styg	2	6	6	5	7	6	11	6	4	9	2	64
Rove beetles (Staphylinidae)	*Tachinus basalis* Erichson	Tach_basa	6	0	0	0	0	0	0	0	0	0	0	6
Rove beetles (Staphylinidae)	*Tachinus elongatus* Gyllenhal	Tach_elon	34	0	0	1	1	0	0	0	0	0	0	36
Rove beetles (Staphylinidae)	*Tachinus frigidus* Erichson	Tach_frig	367	0	1	0	0	1	0	0	0	0	0	369
Rove beetles (Staphylinidae)	*Tachinus fumipennis* (Say)	Tach_fumi	681	0	0	0	0	1	0	0	0	0	0	682

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				Fertilized	Unfertilized	Fertilized	Unfertilized	Fertilized	Unfertilized	Fertilized	Unfertilized	Fertilized	Unfertilized	
Rove beetles (Staphylinidae)	*Tachinus quebecensis* Robert	Tach_queb	102	0	1	0	0	0	0	0	0	0	0	103
Rove beetles (Staphylinidae)	*Tachinus vergatus* Campbell	Tach_verg	1	0	0	0	0	0	0	0	0	0	0	1
Rove beetles (Staphylinidae)	*Tachyporus abdominalis* (Fabricius)	Tacy_abdo	0	0	0	0	1	0	0	0	0	0	0	1
Rove beetles (Staphylinidae)	*Tachyporus borealis* Campbell	Tacy_bore	65	75	79	49	36	23	17	6	20	16	10	396
Rove beetles (Staphylinidae)	*Tachyporus canadensis* Campbell	Tacy_cana	1	9	6	8	2	4	5	6	8	3	2	54
Rove beetles (Staphylinidae)	*Tachyporus flavipennis* Campbell	Tacy_flav	0	70	88	20	19	33	43	9	12	17	6	317
Rove beetles (Staphylinidae)	*Tachyporus inornatus* Campbell	Tacy_inor	0	2	5	2	7	4	6	1	0	0	2	29
Rove beetles (Staphylinidae)	*Tachyporus maculicollis* LeConte	Tacy_macu	0	36	32	17	16	7	11	4	5	4	13	145
Rove beetles (Staphylinidae)	*Tachyporus mexicanus* Sharp	Tacy_mexi	0	2	3	1	1	3	2	0	1	1	2	16
Rove beetles (Staphylinidae)	*Tachyporus nimbicola* Campbell	Tacy_nimb	0	24	22	9	15	5	0	3	2	3	6	89
Rove beetles (Staphylinidae)	*Tachyporus nitidulus* (Fabricius)	Tacy_niti	7	1	2	5	1	6	5	3	7	3	2	42
Rove beetles (Staphylinidae)	*Tachyporus rulomus* Blackwelder	Tacy_rulo	34	81	77	55	22	24	25	32	19	7	8	384
Rove beetles (Staphylinidae)	*Tachyporus stacesmithi* Campbell	Tacy_stac	0	0	1	0	0	0	0	0	0	0	0	1
Rove beetles (Staphylinidae)	*Tympanophorus puncticollis* (Erichson)	Tymp_punc	1	6	5	4	5	1	1	0	3	1	4	31
		Richness	64	53	52	57	56	57	54	54	56	54	55	119
		Catch	4133	666	837	560	576	517	519	419	471	352	376	9426
Spiders (Agelenidae)	*Agelenopsis utahana* (Chamberlin & Ivie)	Agelutah	16	0	0	0	1	1	0	0	0	0	0	18
Spiders (Amaurobiidae)	*Amaurobius borealis* Emerton	Amaubore	288	1	4	4	2	3	4	8	7	0	4	325
Spiders (Amaurobiidae)	*Arctobius agelenoides* (Emerton)	Arctagel	20	0	0	0	0	0	0	0	0	0	0	20
Spiders (Amaurobiidae)	*Callobius nomeus* (Chamberlin)	Callnome	9	0	0	0	1	0	0	0	0	0	0	10
Spiders (Amaurobiidae)	*Cybaeopsis euopla* (Bishop & Crosby)	Cybaeuop	252	128	97	97	112	42	47	56	35	23	34	923
Spiders (Araneidae)	*Araneus iviei* (Archer)	Aranivie	0	0	0	0	0	0	0	0	0	0	1	1
Spiders (Araneidae)	*Araneus saevus* (L. Koch)	Aransaev	0	0	0	0	1	0	0	0	0	0	0	1
Spiders (Araneidae)	*Araneus trifolium* (Hentz)	Arantrif	0	0	0	0	0	0	0	1	0	0	0	1
Spiders (Clubionidae)	*Clubiona bryantae* Gertsch	Clubbrya	0	1	1	0	0	1	1	1	0	1	1	7
Spiders (Clubionidae)	*Clubiona canadensis* Emerton	Clubcana	21	0	0	0	0	0	0	0	0	0	0	21
Spiders (Clubionidae)	*Clubiona johnsoni* Gertsch	Clubjohn	0	0	1	0	0	0	0	0	0	0	0	1
Spiders (Clubionidae)	*Clubiona kulczynskii* Lessert	Clubkulc	2	0	0	0	0	0	0	1	0	0	0	3
Spiders (Corinnidae)	*Castianeira descripta* (Hentz)	Castdesc	0	0	0	0	4	0	0	1	0	0	0	5
Spiders (Dictynidae)	*Argenna obesa* Emerton	Argeobes	0	42	53	76	73	14	24	33	34	11	22	382
Spiders (Dictynidae)	*Dictyna minuta* Emerton	Dictminu	5	0	0	0	0	0	0	0	0	0	0	5
Spiders (Dictynidae)	*Emblyna maxima* (Banks)	Emblmaxi	1	0	0	0	0	0	0	0	0	0	0	1
Spiders (Dictynidae)	*Lathys* sp.	Lathsp	1	0	0	0	0	0	0	0	0	0	0	1
Spiders (Gnaphosidae)	*Drassodes neglectus* (Keyserling)	Drasnegl	0	0	1	0	0	0	0	0	0	0	2	3
Spiders (Gnaphosidae)	*Drassyllus niger* (Banks)	Drasnige	0	1	0	0	0	1	2	0	1	0	1	6
Spiders (Gnaphosidae)	*Gnaphosa borea* Kulczynski	Gnapbore	0	1	3	2	0	0	0	2	0	0	0	8

Table A1. (*continued*).

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				Fertilized	Unfertilized	Fertilized	Unfertilized	Fertilized	Unfertilized	Fertilized	Unfertilized	Fertilized	Unfertilized	
Spiders (Gnaphosidae)	*Gnaphosa brumalis* Thorell	Gnapbrum	3	0	0	0	0	0	0	0	0	0	0	3
Spiders (Gnaphosidae)	*Gnaphosa microps* Holm	Gnapmicr	19	0	0	0	0	0	0	0	0	0	1	20
Spiders (Gnaphosidae)	*Gnaphosa parvula* Banks	Gnapparv	0	0	5	1	2	0	3	2	3	2	1	19
Spiders (Gnaphosidae)	*Haplodrassus hiemalis* (Emerton)	Haplhiem	7	2	3	1	1	3	3	4	1	2	0	27
Spiders (Gnaphosidae)	*Haplodrassus signifer* (C.L. Koch)	Haplsign	0	0	2	0	2	0	2	0	0	0	0	6
Spiders (Gnaphosidae)	*Micaria aenea* Thorell	Micaaene	26	0	0	0	0	0	0	0	0	0	0	26
Spiders (Gnaphosidae)	*Micaria pulicaria* (Sundevall)	Micapuli	8	5	5	3	2	1	0	2	1	0	1	28
Spiders (Gnaphosidae)	*Micaria tripunctata* Holm	Micatrip	1	0	0	0	0	1	0	0	0	0	0	2
Spiders (Gnaphosidae)	*Orodrassus canadensis* Platnick & Shadab	Orodcana	4	0	0	0	0	0	0	0	0	0	0	4
Spiders (Gnaphosidae)	*Zelotes fratris* Chamberlin	Zelofrat	14	27	16	16	17	21	18	12	12	15	7	175
Spiders (Gnaphosidae)	*Zelotes puritanus* Chamberlin	Zelopuri	3	2	0	1	0	0	0	0	0	0	1	7
Spiders (Hahniidae)	*Antistea brunnea* (Emerton)	Antibrun	1	0	1	0	0	0	0	0	0	0	0	2
Spiders (Hahniidae)	*Cicurina arcuata* Keyserling	Cicuarcu	0	0	0	0	1	0	0	1	0	0	0	2
Spiders (Hahniidae)	*Cicurina robusta* Simon	Cicurobu	0	0	0	0	1	1	0	2	0	1	1	6
Spiders (Hahniidae)	*Hahnia cinerea* Emerton	Hahncine	3	0	0	0	2	2	0	1	0	0	0	8
Spiders (Hahniidae)	*Neoantistea magna* (Keyserling)	Neoamagn	1	6	16	7	4	1	4	2	4	1	4	50
Spiders (Linyphiidae)	*Agyneta allosubtilis* Loksa	Agynallo	4	0	0	0	0	0	0	0	0	0	0	4
Spiders (Linyphiidae)	*Agyneta amersaxatilis* Saaristo & Koponen	Agynamer	0	0	3	0	1	1	1	1	0	2	0	9
Spiders (Linyphiidae)	*Agyneta fabra* (Keyserling)	Agynfabr	9	1	0	0	0	0	0	0	0	0	0	10
Spiders (Linyphiidae)	*Agyneta lophophor* (Chamberlin & Ivie)	Agynloph	0	3	2	5	4	2	3	3	4	4	5	35
Spiders (Linyphiidae)	*Agyneta simplex* (Emerton)	Agynsimp	1	10	19	15	13	6	7	7	8	6	1	93
Spiders (Linyphiidae)	*Agyneta* sp.	Agysp	3	1	1	0	0	0	0	0	0	0	0	5
Spiders (Linyphiidae)	*Allomengea dentisetis* (Grube)	Allodent	357	2	3	0	0	4	1	1	0	2	0	370
Spiders (Linyphiidae)	*Aphileta misera* (O. Pickard-Cambridge)	Aphimise	2	0	1	0	0	0	1	3	0	2	0	9
Spiders (Linyphiidae)	*Baryphyma gowerense* (Locket)	Barygowe	0	0	1	2	2	0	1	0	0	0	0	6
Spiders (Linyphiidae)	*Bathyphantes canadensis* (Emerton)	Bathcana	0	0	0	0	0	0	0	1	0	0	0	1
Spiders (Linyphiidae)	*Bathyphantes gracilis* (Blackwall)	Bathgrac	0	0	0	0	0	1	0	0	0	0	0	1
Spiders (Linyphiidae)	*Bathyphantes pallidus* (Banks)	Bathpall	117	0	1	0	0	1	1	0	1	1	0	122
Spiders (Linyphiidae)	*Carorita limnaea* (Crosby & Bishop)	Carolimn	0	0	0	0	0	0	0	0	0	0	1	1
Spiders (Linyphiidae)	*Centromerus sylvaticus* (Blackwall)	Centsylv	0	3	1	1	1	1	3	0	1	0	2	13
Spiders (Linyphiidae)	*Ceraticelus bulbosus* (Emerton)	Cerabulb	0	26	26	12	5	3	7	2	3	1	0	85
Spiders (Linyphiidae)	*Ceraticelus crassiceps* Chamberlin & Ivie	Ceracras	0	8	3	4	0	0	2	0	0	0	0	17

Table A1. (*continued*).

Group	Species	Abbrev.	Forest	Untreated		Herbicide		Mounding		Mounding + herbicide		Mixing + herbicide		Total
				Fertilized	Unfertilized	Fertilized	Unfertilized	Fertilized	Unfertilized	Fertilized	Unfertilized	Fertilized	Unfertilized	
Spiders (Linyphiidae)	*Ceraticelus fissiceps* (O. Pickard-Cambridge)	Cerafiss	20	2	6	2	0	0	0	0	1	0	0	31
Spiders (Linyphiidae)	*Ceraticelus laetus* (O. Pickard-Cambridge)	Ceralaet	5	6	14	12	8	4	1	0	2	3	2	57
Spiders (Linyphiidae)	*Ceraticelus rugosus* (Crosby)	Cerarugo	1	0	0	0	0	0	0	0	0	0	0	1
Spiders (Linyphiidae)	*Ceraticelus similis* (Banks)	Cerasimi	0	16	20	7	10	1	6	0	1	2	4	67
Spiders (Linyphiidae)	*Ceratinella buna* Chamberlin	Cerabuna	7	6	8	4	3	4	6	6	2	3	2	51
Spiders (Linyphiidae)	*Ceratinella parvula* (Fox)	Ceraparv	0	0	0	0	0	0	1	0	0	0	0	1
Spiders (Linyphiidae)	*Ceratinops inflatus* (Emerton)	Cerainfl	0	0	1	0	1	0	0	1	1	0	0	4
Spiders (Linyphiidae)	*Ceratinopsis labradorensis* Emerton	Ceralabr	1	2	0	0	1	0	1	1	0	0	1	7
Spiders (Linyphiidae)	*Cercidia prominens* (Westring)	Cercprom	0	1	0	2	1	2	1	1	5	2	1	16
Spiders (Linyphiidae)	*Cheniseo sphagnicultor* Bishop & Crosby	Chenspha	0	0	0	1	2	0	0	0	0	0	0	3
Spiders (Linyphiidae)	*Cnephalocotes obscurus* (Blackwall)	Cnepobsc	0	1	0	0	1	0	1	0	0	0	0	3
Spiders (Linyphiidae)	*Dicymbium elongatum* Emerton	Dicyelon	0	0	0	0	0	0	0	0	0	1	0	1
Spiders (Linyphiidae)	*Diplocentria bidentata* (Emerton)	Diplbide	117	36	48	35	42	16	19	9	9	7	4	342
Spiders (Linyphiidae)	*Diplocentria rectangulata* (Emerton)	Diplrect	13	0	0	0	0	0	0	0	0	0	0	13
Spiders (Linyphiidae)	*Diplocentria retinax* (Crosby & Bishop)	Diplreti	1	0	0	0	0	0	0	0	0	0	0	1
Spiders (Linyphiidae)	*Diplocephalus subrostratus* (O. Pickard-Cambridge)	Diplsubr	5	0	0	0	0	0	0	1	0	0	0	6
Spiders (Linyphiidae)	*Dismodicus alticeps* Chamberlin & Ivie	Dismalti	2	0	0	0	0	0	0	0	0	0	0	2
Spiders (Linyphiidae)	*Drapetisca alteranda* Chamberlin	Drapalte	1	0	0	0	0	0	0	0	0	0	0	1
Spiders (Linyphiidae)	*Erigone aletris* Crosby & Bishop	Erigalet	0	0	0	0	1	0	0	0	0	3	2	6
Spiders (Linyphiidae)	*Erigone atra* Blackwall	Erigatra	1	1	1	13	3	2	3	2	1	10	14	51
Spiders (Linyphiidae)	*Erigone blaesa* Crosby & Bishop	Erigblae	0	0	0	3	3	0	0	0	0	1	0	7
Spiders (Linyphiidae)	*Erigone dentigera* O. Pickard-Cambridge	Erigdent	0	0	0	4	1	0	2	1	1	4	3	16
Spiders (Linyphiidae)	*Erigone* sp.	Erigsp	0	0	0	0	0	0	0	0	0	0	2	2
Spiders (Linyphiidae)	*Gonatium crassipalpum* Bryant	Gonacras	0	6	3	4	0	3	6	1	6	1	1	31
Spiders (Linyphiidae)	*Grammonota angusta* Dondale	Gramangu	2	0	0	0	0	0	0	0	0	0	0	2
Spiders (Linyphiidae)	*Grammonota capitata* Emerton	Gramcapi	0	1	1	0	1	1	0	0	0	0	0	4
Spiders (Linyphiidae)	*Grammonota gentilis* Banks	Gramgent	0	0	0	0	0	0	0	0	0	0	1	1
Spiders (Linyphiidae)	*Grammonota gigas* (Banks)	Gramgiga	0	17	30	7	51	0	0	2	1	1	2	111
Spiders (Linyphiidae)	*Helophora insignis* (Blackwall)	Heloinsi	15	0	0	0	0	0	0	0	0	0	0	15
Spiders (Linyphiidae)	*Hybauchenidium cymbadentatum* (Crosby & Bishop)	Hybacymb	0	0	0	0	1	0	0	1	0	0	0	2
Spiders (Linyphiidae)	*Hypselistes florens* (O. Pickard-Cambridge)	Hypsflor	5	0	0	0	0	1	0	2	0	0	1	9

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Table A1. (*continued*).

Group	Species	Abbrev.	Forest	Untreated		Herbicide		Mounding		Mounding + herbicide		Mixing + herbicide		Total
				Fertilized	Unfertilized	Fertilized	Unfertilized	Fertilized	Unfertilized	Fertilized	Unfertilized	Fertilized	Unfertilized	
Spiders (Linyphiidae)	*Idionella anomola* (Gertsh & Ivie)	Idioanom	0	0	0	0	1	0	0	0	0	0	0	1
Spiders (Linyphiidae)	*Improphantes complicatus* (Emerton)	Imprcomp	6	0	0	0	0	0	0	0	0	0	0	6
Spiders (Linyphiidae)	*Islandiana longisetosa* (Emerton)	Islalong	0	0	0	0	0	0	0	0	0	0	1	1
Spiders (Linyphiidae)	*Islandiana princeps* Braendegaard	Islaprin	0	0	0	0	1	1	0	0	0	0	0	2
Spiders (Linyphiidae)	*Kaestneria pullata* (O. Pickard-Cambridge)	Kaespull	0	0	0	0	0	0	0	0	0	1	0	1
Spiders (Linyphiidae)	*Lepthyphantes alpinus* (Emerton)	Leptalpi	40	0	0	0	0	0	0	0	0	0	0	40
Spiders (Linyphiidae)	*Lepthyphantes intricatus* (Emerton)	Leptintr	77	2	2	3	0	2	1	2	1	4	2	96
Spiders (Linyphiidae)	Linyphiidae sp1	Linysp1	0	0	0	0	0	1	0	0	0	0	0	1
Spiders (Linyphiidae)	Linyphiidae sp2	Linysp2	0	1	0	0	0	0	0	0	0	0	0	1
Spiders (Linyphiidae)	Linyphiidae sp3	Linysp3	0	1	0	0	0	0	0	0	0	0	0	1
Spiders (Linyphiidae)	Linyphiidae sp4	Linysp4	0	0	0	0	1	0	0	0	0	0	0	1
Spiders (Linyphiidae)	Linyphiidae sp5	Linysp5	1	0	0	0	0	0	0	0	0	0	0	1
Spiders (Linyphiidae)	Linyphiidae sp6	Linysp6	3	2	0	5	12	0	2	0	0	1	1	26
Spiders (Linyphiidae)	*Macrargus multesimus* (O. Pickard-Cambridge)	Macrmult	1	0	0	0	0	0	0	0	0	0	0	1
Spiders (Linyphiidae)	*Maro amplus* Dondale & Buckle	Maroampl	1	0	0	0	0	0	0	0	0	0	0	1
Spiders (Linyphiidae)	*Mermessus trilobatus* (Emerton)	Mermtril	2	31	34	38	40	19	26	28	21	25	23	287
Spiders (Linyphiidae)	*Microlinyphia mandibulata* (Emerton)	Micrmand	0	4	3	2	1	3	3	3	1	0	0	20
Spiders (Linyphiidae)	*Microneta* viaria (Blackwall)	Micrviar	31	0	1	0	0	0	1	0	0	0	1	34
Spiders (Linyphiidae)	*Neriene clathrata* (Sundevall)	Nericlat	3	1	0	0	0	0	0	0	0	0	0	4
Spiders (Linyphiidae)	*Neriene radiata* (Walckanaer)	Neriradi	1	0	0	0	0	0	0	0	0	0	0	1
Spiders (Linyphiidae)	*Oedothorax trilobatus* (Banks)	Oedotril	1	0	0	0	0	1	0	0	0	0	0	2
Spiders (Linyphiidae)	*Oreonetides rectangulatus* (Emerton)	Oreorect	0	1	1	1	0	0	0	0	1	2	0	6
Spiders (Linyphiidae)	*Oreonetides vaginatus* (Thorell)	Oreovagi	17	0	0	0	0	0	0	0	0	0	0	17
Spiders (Linyphiidae)	*Oreophantes recurvatus* (Emerton)	Oreorecu	1	0	0	0	0	0	0	0	0	0	0	1
Spiders (Linyphiidae)	*Oryphantes aliquantulus* Duperre & Paquin	Orypaliq	2	0	0	0	0	0	0	0	0	0	0	2
Spiders (Linyphiidae)	*Pelecopsis moesta* (Banks)	Pelemoes	0	2	0	3	1	0	0	0	0	0	0	6
Spiders (Linyphiidae)	*Phlattothrata flagellata* (Emerton)	Phlaflag	0	1	0	6	17	0	1	0	0	0	2	27
Spiders (Linyphiidae)	*Pityohyphantes subarcticus* Chamberlin & Ivie	Pitysuba	8	0	0	0	0	0	0	0	0	0	0	8
Spiders (Linyphiidae)	*Pocadicnemis americana* Millidge	Pocaamer	80	7	4	3	5	0	4	0	1	0	1	105
Spiders (Linyphiidae)	*Poeciloneta variegata* (Blackwall)	Poecvari	3	0	0	0	0	0	0	0	0	0	0	3
Spiders (Linyphiidae)	*Porrhomma terrestre* (Emerton)	Porrterr	3	0	0	0	0	2	1	0	0	2	0	8
Spiders (Linyphiidae)	*Praestigia kulczynskii* Eskov	Praekulc	0	0	1	1	0	0	0	0	0	0	0	2

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Table A1. (*continued*).

Group	Species	Abbrev.	Forest	Untreated		Herbicide		Mounding		Mounding + herbicide		Mixing + herbicide		Total
				Fertilized	Unfertilized	Fertilized	Unfertilized	Fertilized	Unfertilized	Fertilized	Unfertilized	Fertilized	Unfertilized	
Spiders (Linyphiidae)	*Satilatlas gertschi* Millidge	Satigert	19	0	0	0	0	0	0	0	0	0	0	19
Spiders (Linyphiidae)	*Sciastes truncatus* (Emerton)	Sciatrun	191	2	2	2	0	3	6	6	2	1	1	216
Spiders (Linyphiidae)	*Scirites pectinatus* (Emerton)	Scirpect	0	24	15	17	13	0	2	4	2	2	0	79
Spiders (Linyphiidae)	*Scironis tarsalis* (Emerton)	Scirtars	0	48	54	71	49	18	21	11	17	11	15	315
Spiders (Linyphiidae)	*Scotinotylus pallidus* (Emerton)	Scotpall	15	0	0	0	1	2	0	1	1	0	0	20
Spiders (Linyphiidae)	*Scotinotylus sacer* (Crosby)	Scotsace	4	0	0	0	0	0	0	0	0	0	0	4
Spiders (Linyphiidae)	*Scotinotylus vernalis* (Emerton)	Scotvern	0	0	0	0	0	0	0	0	1	0	0	1
Spiders (Linyphiidae)	*Scyletria inflata* Bishop & Crosby	Scylinfl	0	3	8	0	3	0	0	2	1	0	1	18
Spiders (Linyphiidae)	*Sisicottus montanus* (Emerton)	Sisimont	26	0	0	0	0	0	0	0	0	0	0	26
Spiders (Linyphiidae)	*Sisis rotundus* (Emerton)	Sisirotu	12	0	0	0	0	0	0	0	0	0	0	12
Spiders (Linyphiidae)	*Soucron arenarium* (Emerton)	Soucaren	0	0	0	0	0	0	0	0	0	1	0	1
Spiders (Linyphiidae)	*Souessa spinifera* (O. Pickard-Cambridge)	Souespin	0	0	0	0	0	1	0	0	0	0	1	2
Spiders (Linyphiidae)	*Stemonyphantes blauveltae* Gertsch	Stemblau	0	1	2	0	0	3	7	4	7	5	3	32
Spiders (Linyphiidae)	*Styloctetor compar* (Westring)	Stylocomp	1	11	5	9	4	2	3	1	1	2	1	40
Spiders (Linyphiidae)	*Tapinocyba bicarinata* (Emerton)	Tapibica	1	0	1	0	1	0	1	0	0	0	0	4
Spiders (Linyphiidae)	*Tapinocyba cameroni* Duperre & Paquin	Tapicame	1	0	0	0	0	0	0	0	0	0	0	1
Spiders (Linyphiidae)	*Tapinocyba minuta* (Emerton)	Tapiminu	9	1	2	0	3	0	1	0	0	0	0	16
Spiders (Linyphiidae)	*Tapinocyba prima* Duperre & Paquin	Tapiprim	4	0	6	3	5	1	1	0	0	0	0	20
Spiders (Linyphiidae)	*Tapinocyba simplex* (Emerton)	Tapisimp	4	13	12	12	16	6	8	2	4	0	2	79
Spiders (Linyphiidae)	*Tapinocyba* sp1	Tapisp1	0	5	7	3	5	0	5	1	0	2	0	28
Spiders (Linyphiidae)	*Tapinocyba* spp.	Tapispp	0	0	0	2	1	0	0	0	0	0	0	3
Spiders (Linyphiidae)	*Tenuiphantes zebra* (Emerton)	Tenuzebr	0	0	1	0	0	0	0	0	0	0	0	1
Spiders (Linyphiidae)	*Tunagyna debilis* (Banks)	Tunadebi	1	28	51	50	24	12	14	12	5	2	19	218
Spiders (Linyphiidae)	*Walckenaeria atrotibialis* (O. Pickard-Cambridge)	Walcatro	15	1	3	1	1	0	0	0	0	1	1	23
Spiders (Linyphiidae)	*Walckenaeria castanea* (Emerton)	Walccast	13	3	4	6	6	3	3	2	2	3	6	51
Spiders (Linyphiidae)	*Walckenaeria communis* (Emerton)	Walccomm	16	3	5	1	3	1	2	2	2	0	2	37
Spiders (Linyphiidae)	*Walckenaeria digitata* (Emerton)	Walcdigi	4	3	2	1	0	6	3	1	7	1	1	29
Spiders (Linyphiidae)	*Walckenaeria directa* (O. Pickard-Cambridge)	Walcdire	18	0	1	0	0	0	0	0	0	0	0	19
Spiders (Linyphiidae)	*Walckenaeria exigua* Millidge	Walcexig	0	0	0	0	1	0	0	0	0	0	0	1
Spiders (Linyphiidae)	*Walckenaeria fallax* Millidge	Walcfall	0	0	0	1	0	0	0	0	0	0	0	1
Spiders (Linyphiidae)	*Walckenaeria lepida* (Kulczynski)	Walclepi	1	0	0	1	0	1	0	0	0	0	0	3

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Table A1. (*continued*).

Group	Species	Abbrev.	Forest	Untreated		Herbicide		Mounding		Mounding + herbicide		Mixing + herbicide		Total
				Fertilized	Unfertilized	Fertilized	Unfertilized	Fertilized	Unfertilized	Fertilized	Unfertilized	Fertilized	Unfertilized	
Spiders (Linyphiidae)	*Walckenaeria minuta* (Emerton)	Walcminu	2	0	0	2	1	0	1	0	0	0	0	6
Spiders (Linyphiidae)	*Walckenaeria pallida* (Emerton)	Walcpall	1	0	0	0	0	0	0	0	0	0	0	1
Spiders (Linyphiidae)	*Walckenaeria palustris* Millidge	Walcpalu	2	3	1	3	2	0	2	0	1	0	1	15
Spiders (Linyphiidae)	*Walckenaeria spiralis* (Emerton)	Walcspir	0	3	7	7	15	5	1	4	1	1	7	51
Spiders (Liocranidae)	*Agroeca ornata* Banks	Agroorna	71	3	0	1	1	0	1	0	0	0	0	77
Spiders (Lycosidae)	*Alopecosa aculeata* (Clerck)	Alopacul	50	175	157	194	190	108	77	93	98	74	74	1290
Spiders (Lycosidae)	*Arctosa alpigena* (Doleschall)	Arctalpi	0	1	0	1	0	0	0	0	0	0	0	2
Spiders (Lycosidae)	*Arctosa emertoni* Gertsch	Arctemer	3	19	6	14	24	15	15	20	12	14	19	161
Spiders (Lycosidae)	*Arctosa raptor* (Kulczynski)	Arctrapt	0	1	2	0	0	1	1	0	0	2	0	7
Spiders (Lycosidae)	*Pardosa distincta* (Blackwall)	Parddist	1	57	80	73	46	14	21	34	40	27	22	415
Spiders (Lycosidae)	*Pardosa fuscula* (Thorell)	Pardfusc	1	1	3	2	3	8	2	2	2	7	5	36
Spiders (Lycosidae)	*Pardosa hyperborea* (Thorell)	Pardhype	10	22	30	24	15	8	6	6	8	13	6	148
Spiders (Lycosidae)	*Pardosa mackenziana* (Keyserling)	Pardmack	115	1	0	0	0	4	1	0	0	0	1	122
Spiders (Lycosidae)	*Pardosa modica* (Blackwall)	Pardmodi	0	7	5	3	8	1	1	0	3	2	1	31
Spiders (Lycosidae)	*Pardosa moesta* Banks	Pardmoes	9	977	867	443	518	179	229	124	135	113	140	3734
Spiders (Lycosidae)	*Pardosa mulaiki* Gertsch	Pardmula	0	1	1	0	1	0	0	0	0	1	2	6
Spiders (Lycosidae)	*Pardosa ontariensis* Gertsch	Pardonta	0	0	1	1	1	0	0	0	1	2	0	6
Spiders (Lycosidae)	*Pardosa tesquorum* (Odenwall)	Pardtesq	0	0	0	0	1	0	0	1	0	0	0	2
Spiders (Lycosidae)	*Pardosa uintana* Gertsch	Parduint	74	0	0	1	0	1	1	0	0	1	1	79
Spiders (Lycosidae)	*Pardosa xerampelina* (Keyserling)	Pardxera	2	0	0	3	3	11	4	14	2	5	5	49
Spiders (Lycosidae)	*Pirata bryantae* Kurata	Pirabrya	48	0	0	0	0	0	1	0	0	0	0	49
Spiders (Lycosidae)	*Pirata piraticus* (Clerck)	Pirapira	5	1	2	3	1	0	0	0	0	0	1	13
Spiders (Lycosidae)	*Pirata* sp.	Pirasp	0	0	0	1	0	0	0	0	0	1	0	2
Spiders (Lycosidae)	*Piratula canadensis* (Dondale & Redner)	Piracana	3	1	1	1	0	0	0	1	0	0	0	7
Spiders (Lycosidae)	*Trochosa terricola* Thorell	Trocterr	61	48	51	71	75	65	46	49	65	46	39	616
Spiders (Mimetidae)	*Ero canionis* Chamberlin & Ivie	Erocani	8	0	1	0	1	0	0	1	1	0	0	12
Spiders (Philodromidae)	*Ebo bucklei* Platnick	Ebobuck	0	0	0	0	0	0	0	0	1	0	0	1
Spiders (Philodromidae)	*Ebo iviei* Sauer & Platnick	Eboivie	0	5	5	1	4	2	0	1	2	0	0	20
Spiders (Philodromidae)	*Philodromus mysticus* Dondale & Redner	Philmyst	1	0	0	0	0	0	0	0	0	0	0	1
Spiders (Philodromidae)	*Philodromus rufus quartus* Dondale & Redner	Philrufu	3	0	0	0	0	0	0	0	2	0	0	5
Spiders (Philodromidae)	*Thanatus coloradensis* Keyserling	Thancolo	0	1	1	1	1	0	0	0	0	0	0	4
Spiders (Philodromidae)	*Thanatus formicinus* (Clerck)	Thanform	0	9	5	9	7	6	10	1	6	11	6	70
Spiders (Philodromidae)	*Thanatus rubicellus* Mello-Leitao	Thanrubi	0	8	5	18	21	13	10	19	21	9	21	145
Spiders (Philodromidae)	*Thanatus striatus* C.L. Koch	Thanstri	0	1	1	3	0	1	0	2	1	3	3	15
Spiders (Philodromidae)	*Tibellus maritimus* (Menge)	Tibemari	0	0	0	0	0	1	0	2	3	3	0	9
Spiders (Philodromidae)	*Tibellus oblongus* (Walkenaer)	Tibeoblo	1	0	0	0	0	0	0	1	0	1	1	4
Spiders (Phrurolithidae)	*Scotinella pugnata* (Emerton)	Scotpugn	0	1	0	0	0	1	1	4	3	0	0	10

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Table A1. (*concluded*).

Group	Species	Abbrev.	Forest	Untreated		Herbicide		Mounding		Mounding + herbicide		Mixing + herbicide		Total
				Fertilized	Unfertilized	Fertilized	Unfertilized	Fertilized	Unfertilized	Fertilized	Unfertilized	Fertilized	Unfertilized	
Spiders (Salticidae)	*Attulus (=Sitticus) cutleri* (Proszynski)	Sittcutl	0	1	1	0	2	3	0	1	0	0	0	8
Spiders (Salticidae)	*Eris militaris* (Hentz)	Erismili	0	0	0	0	0	1	0	0	0	0	0	1
Spiders (Salticidae)	*Euophrys monadnock* Emerton	Euopmona	0	1	1	0	0	0	1	0	1	0	0	4
Spiders (Salticidae)	*Evarcha proszynskii* Marusik & Logunov	Evarpros	1	1	1	1	0	0	0	1	0	0	1	6
Spiders (Salticidae)	*Neon nelli* (G.W. Peckham & E.G. Peckham)	Neonnell	11	0	1	0	0	0	1	0	0	1	0	14
Spiders (Salticidae)	*Pelegrina flavipes* (G.W. Peckham & E.G. Packham)	Peleflav	7	0	0	0	0	0	0	0	0	0	0	7
Spiders (Salticidae)	*Pelegrina* sp.	Pelesp	1	0	0	0	0	0	0	0	0	0	0	1
Spiders (Salticidae)	*Phidippus cryptus* Edwards	Phidcryp	0	3	1	1	2	1	1	0	1	0	0	10
Spiders (Salticidae)	*Talavera minuta* (Banks)	Talaminu	6	2	2	3	3	2	0	2	2	0	0	22
Spiders (Tetragnathidae)	*Pachygnatha clercki* Sundevall	Pachcler	0	0	1	0	0	0	0	0	0	0	0	1
Spiders (Tetragnathidae)	*Pachygnatha tristriata* C.L. Koch	Pachtris	0	0	0	0	0	0	2	0	1	0	0	3
Spiders (Tetragnathidae)	*Pachygnatha xanthostoma* C.L. Koch	Pachxant	1	0	0	0	0	0	0	0	0	0	0	1
Spiders (Theridiidae)	*Arctachaea* sp1	Arctsp1	0	0	0	0	0	1	0	0	1	0	1	3
Spiders (Theridiidae)	*Crustulina sticta* (O. Pickard-Cambridge)	Crusstic	0	0	0	0	0	0	0	2	0	0	0	2
Spiders (Theridiidae)	*Euryopis argentea* Emerton	Euryarge	25	0	0	0	0	0	0	0	0	0	0	25
Spiders (Theridiidae)	*Robertus arcticus* (Chamberlin & Ivie)	Robearct	0	16	25	26	26	5	12	13	14	3	22	162
Spiders (Theridiidae)	*Robertus banksi* (Kaston)	Robebank	0	2	1	0	1	0	0	1	0	0	1	6
Spiders (Theridiidae)	*Robertus borealis* (Kaston)	Robebore	0	0	0	0	1	0	0	0	0	0	0	1
Spiders (Theridiidae)	*Robertus crosbyi* (Kaston)	Robecros	0	0	0	0	1	0	0	0	0	0	0	1
Spiders (Theridiidae)	*Robertus fuscus* (Emerton)	Robefusc	11	0	1	1	0	1	2	0	0	0	1	17
Spiders (Theridiidae)	Theridiidae spp	Thersp	0	0	1	0	0	0	0	0	0	0	0	1
Spiders (Thomisidae)	*Ozyptila gertschi* Kurata	Ozypgert	0	0	0	0	0	0	0	1	0	0	0	1
Spiders (Thomisidae)	*Ozyptila sincera canadensis* Dondale & Redner	Ozypsinc	9	1	1	0	0	0	0	0	1	0	0	12
Spiders (Thomisidae)	*Xysticus britcheri* Gertsch	Xystbrit	0	2	5	2	3	1	0	3	0	1	2	19
Spiders (Thomisidae)	*Xysticus canadensis* Gertsch	Xystcana	188	0	1	3	0	3	2	1	2	1	3	204
Spiders (Thomisidae)	*Xysticus discursans* Keyserling	Xystdisc	1	0	0	0	0	0	1	1	0	1	1	5
Spiders (Thomisidae)	*Xysticus ellipticus* Turnbull, Dondale & Redner	Xystelli	0	141	101	65	50	13	25	10	8	6	6	425
Spiders (Thomisidae)	*Xysticus emertoni* Keyserling	Xystemer	1	29	51	43	46	36	27	30	38	23	27	351
Spiders (Thomisidae)	*Xysticus ferox* (Hentz)	Xystfero	0	67	67	43	36	30	34	28	32	19	27	383
Spiders (Thomisidae)	*Xysticus luctuosus* (Blackwall)	Xystluct	20	0	0	1	0	0	0	0	0	1	0	22
Spiders (Thomisidae)	*Xysticus obscurus* Collett	Xystobsc	27	0	0	0	0	0	0	0	0	0	0	27
Spiders (Thomisidae)	*Xysticus triguttatus* Keyserling	Xysttrig	0	1	0	1	0	1	0	0	2	1	1	7
Spiders (Titanoecidae)	*Titanoeca nivalis* Simon	Titaniva	0	0	0	0	0	0	1	0	0	0	0	1
		Richness	117	92	98	88	96	82	85	83	76	74	82	216
		Catch	2810	2177	2122	1653	1707	775	838	730	733	571	662	14 771

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Table A2. Environmental variables collected from 1 m^2 plots surrounding each pitfall trap from undisturbed forest and three reclamation sites near Cold Lake, Alberta.

Site	Block	Trap	Area	Treatment	Fertilization	Organic matter depth (cm) — OMD	Light transmission index — PAR	Soil temperature index — Soil_T	Bare soil cover (%) — Bare	Litter material cover (%) — Litter	Total plant cover (%) — Plant	Coarse woody material cover (%) — CWM	Total overstory tree cover (%) — Tree	Total shrub cover (%) — Shrub	Total forb cover (%) — Forb	Total grass cover (%) — Grass	Total sedge cover (%) — Sedge	Total moss cover (%) — Moss
D63	D63.01	D63-01-1	Pad	MxHb	Unfertilized	0	0.120540801	0.837 534 988	0	0	100	0	0	0	90	10	0	0
D63	D63.01	D63-01-2	Pad	MxHb	Unfertilized	0	0.245 978 206	0.798 624 033	0	0	100	0	0	0	95	5	0	0
D63	D63.02	D63-02-1	Pad	Ut	Fertilized	6.5	0.305 854 815	0.794 049 298	0	10	90	0	0	0	30	40	0	0
D63	D63.02	D63-02-2	Pad	Ut	Fertilized	1	0.455 215 933	0.759 892 993	0	5	95	0	0	0	20	50	0	0
D63	D63.03	D63-03-1	Pad	Hb	Unfertilized	2.5	0.84 677 572	0.86 120 558	1	98	2	0	0	2	0	0	0	0
D63	D63.03	D63-03-2	Pad	Hb	Unfertilized	2.5	0.877 307 712	0.803 092 535	2	95	2	0	0	2	0	0	0	0.1
D63	D63.04	D63-04-1	Pad	Md	Fertilized	0	0.309 189 886	0.879 668 738	10	0	90	0	0	1	70	10	0	0
D63	D63.04	D63-04-2	Pad	Md	Fertilized	0	0.551 569 444	0.95 299 043	15	0	85	0	0	2	60	15	0	0
D63	D63.05	D63-05-1	Pad	Ut	Unfertilized	1.5	0.412 317 969	0.86 397 769	0	10	85	0	0	7	50	10	0	0
D63	D63.05	D63-05-2	Pad	Ut	Unfertilized	1	0.378 908 971	0.780 766 595	0	0	100	0	0	7	70	15	0	0
D63	D63.06	D63-06-1	Pad	Hb	Fertilized	1	0.51 271 433	0.904 066 669	2	90	8	0	0	6	3	0.1	0	0.1
D63	D63.06	D63-06-2	Pad	Hb	Fertilized	2	0.877 211 473	0.833 353 128	3	82	15	0	0	3	6	0.1	0	0
D63	D63.07	D63-07-1	Pad	Md	Fertilized	0	0.714 925 907	1.04 495 691	15	0	85	0	0	1	70	10	2	0
D63	D63.07	D63-07-2	Pad	Md	Fertilized	0	0.458 137 418	0.897 388 335	8	0	92	0	0	10	60	10	2	0
D63	D63.08	D63-08-1	Pad	MxHb	Unfertilized	0	0.350 328 771	1.021 070 264	1	0	99	0	0	2	80	15	2	0
D63	D63.08	D63-08-2	Pad	MxHb	Unfertilized	0	0.355 385 904	0.917 254 706	0	0	100	0	0	3	90	5	1	0
D63	D63.09	D63-09-1	Pad	MdHb	Unfertilized	0	0.46 268 908	0.971 190 193	7	0	93	0	0	6	5	80	5	0
D63	D63.09	D63-09-2	Pad	MdHb	Unfertilized	0	0.573 130 824	0.909 217 571	8	0	92	0	0	3	75	10	5	0
D63	D63.10	D63-10-1	Pad	Hb	Unfertilized	0.5	0.803 798 066	0.911 678 346	0	95	6	0	0	6	0	0	0	0
D63	D63.10	D63-10-2	Pad	Hb	Unfertilized	2	0.849 663 591	0.853 814 442	0	85	10	0	0	2	7	0	0	5
D63	D63.11	D63-11-1	Pad	Ut	Fertilized	1	0.243 718 782	0.849 345 226	0	0	100	0	0	5	50	30	0	10
D63	D63.11	D63-11-2	Pad	Ut	Fertilized	3	0.36 881 196	0.816 990 329	0	0	100	0	0	0	40	25	0	10
D63	D63.12	D63-12-1	Pad	Md	Unfertilized	0	0.499 547 676	1.001 220 081	8	0	92	0	0	1	15	80	0	0
D63	D63.12	D63-12-2	Pad	Md	Unfertilized	0	0.537 794 072	0.90 485 103	8	0	92	0	0	1	20	70	0	0
D63	D63.13	D63-13-1	Pad	Hb	Fertilized	0.5	0.812 646 633	0.898 301 337	2	90	5	0	0	1	0	0	0	5
D63	D63.13	D63-13-2	Pad	Hb	Fertilized	2.5	0.637 768 555	0.875 180 971	1	95	2	0	0	2	0	0	0	0.1
D63	D63.14	D63-14-1	Pad	MdHb	Fertilized	0	0.457 693 673	0.983 964 036	7	0	93	0	0	1	80	15	0	0
D63	D63.14	D63-14-2	Pad	MdHb	Fertilized	0	0.231 427 213	0.913 438 643	8	0	92	0	0	0	40	30	0	0
D63	D63.15	D63-15-1	Pad	Ut	Unfertilized	2	0.323 837 629	0.927 154 759	0	0	100	0	0	1	5	95	0	10
D63	D63.15	D63-15-2	Pad	Ut	Unfertilized	1.5	0.268 982 289	0.873 117 663	0	0	100	0	0	0	30	70	1	0
D63	D63.16	D63-16-1	Pad	MxHb	Unfertilized	0	0.295 094 709	1.046 499 764	1	0	99	0	0	0	70	15	0	0
D63	D63.16	D63-16-2	Pad	MxHb	Unfertilized	0	0.353 404 705	0.96 781 886	0	0	100	0	0	0	75	10	0	0
D63	D63.17	D63-17-1	Pad	Md	Unfertilized	0	0.538 279 781	0.996 751 507	15	85	0	0	0	1	10	85	1	0
D63	D63.17	D63-17-2	Pad	Md	Unfertilized	0	0.521 578 865	0.953 582 631	7	0	93	0	0	2	5	80	5	0
D63	D63.18	D63-18-1	Pad	MxHb	Fertilized	0	0.559 499 707	1.074 697 157	5	0	95	0	0	2	90	2	1	0
D63	D63.18	D63-18-2	Pad	MxHb	Fertilized	0	0.515 783 589	1.048 371 657	5	0	95	0	0	2	90	3	1	0
D63	D63.19	D63-19-1	Pad	MdHb	Unfertilized	0	0.673 658 499	1.088 567 767	25	0	75	0	0	0	25	25	50	0
D63	D63.19	D63-19-2	Pad	MdHb	Unfertilized	0	0.575 365 191	0.971 142 026	20	0	80	0	0	2	16	10	60	0

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Table A2. (*continued*).

Site	Block	Trap	Area	Treatment	Fertilization	Organic matter depth (cm) — OMD	Light transmission index — PAR	Soil temperature index — Soil_T	Bare soil cover (%) — Bare	Litter material cover (%) — Litter	Total plant cover (%) — Plant	Coarse woody material cover (%) — CWM	Total overstory tree cover (%) — Tree	Total shrub cover (%) — Shrub	Total forb cover (%) — Forb	Total grass cover (%) — Grass	Total sedge cover (%) — Sedge	Total moss cover (%) — Moss
D63	D63.20	D63-20-1	Pad	MdHb	Fertilized	0	0.724 786 087	1.015 827 045	15	0	85	0	0	10	7	10	5	0
D63	D63.20	D63-20-2	Pad	MdHb	Fertilized	0	0.525 833 121	0.962 290 047	20	0	80	0	0	8	20	10	30	0
D63	D63.21	D63-21-1	Pad	Hb	Unfertilized	1	0.746 000 123	0.892 099 869	3	98	2	0	0	2	0	0	0	0
D63	D63.21	D63-21-2	Pad	Hb	Unfertilized	2.5	0.845 394 642	0.814 787 258	2	98	2	0	0	2	1	0	0	0
D63	D63.22	D63-22-1	Pad	Md	Fertilized	0	0.328 286 616	0.981 502 761	5	0	95	0	0	5	65	15	0	0
D63	D63.22	D63-22-2	Pad	Md	Fertilized	0	0.464 613 206	0.842 411 839	15	0	85	0	0	0	70	20	0	0
D63	D63.23	D63-23-1	Pad	Hb	Fertilized	2.5	0.800 105 343	0.874 010 738	2	95	5	0	0	2	3	0.1	0	0
D63	D63.23	D63-23-2	Pad	Hb	Fertilized	1.5	0.882 217 488	0.847 967 596	8	90	2	0	0	2	1	0	0	0
D63	D63.24	D63-24-1	Pad	MdHb	Unfertilized	0	0.334 931 685	1.015 192 226	10	0	90	0	0	2	85	2	1	0
D63	D63.24	D63-24-2	Pad	MdHb	Unfertilized	0	0.390 984 041	0.863 553 458	3	0	97	0	0	1	85	15	2	0
D63	D63.25	D63-25-1	Pad	MdHb	Fertilized	0	0.517 781 282	1.023 042 868	4	0	96	0	0	2	90	2	0	0
D63	D63.25	D63-25-2	Pad	MdHb	Fertilized	0	0.441 006 424	0.866 968 309	10	0	85	0	0	2	90	5	0	0
D63	D63.26	D63-26-1	Pad	MxHb	Unfertilized	0	0.366 083 364	1.005 421 203	0	0	100	0	0	1	95	2	1	0
D63	D63.26	D63-26-2	Pad	MxHb	Unfertilized	0	0.373 060 507	0.945 067 668	0	0	100	0	0	1	95	2	1	0
D63	D63.27	D63-27-1	Pad	Md	Unfertilized	0	0.393 158 522	0.978 774 262	5	0	95	0	0	2	90	5	0	0
D63	D63.27	D63-27-2	Pad	Md	Unfertilized	0	0.445 363 874	0.938 214 141	25	0	75	0	0	10	70	2	0	0
D63	D63.28	D63-28-1	Pad	Md	Fertilized	0	0.23 605 688	0.95 824 367	1	0	99	0	0	40	20	10	0	0
D63	D63.28	D63-28-2	Pad	Md	Fertilized	0	0.656 058 953	0.909 312 385	20	0	80	0	0	1	50	10	0	0
D63	D63.29	D63-29-1	Pad	Ut	Fertilized	0.5	0.363 996 726	0.815 825 251	0	4	96	0	0	1	85	10	0	0
D63	D63.29	D63-29-2	Pad	Ut	Fertilized	1.5	0.268 589 749	0.790 386 669	0	2	98	0	0	0	85	15	0	0.1
D63	D63.30	D63-30-1	Pad	MxHb	Fertilized	0	0.251 244 829	1.035 815 948	5	0	95	0	0	1	90	5	0	0
D63	D63.30	D63-30-2	Pad	MxHb	Fertilized	0	0.22 255 262	0.952 631 995	0	0	100	0	0	1	85	15	0	0
D63	D63.31	D63-31-1	Pad	Ut	Fertilized	1.5	0.404 148 073	0.831 780 226	0	2	98	0	0	0	20	80	0	0.1
D63	D63.31	D63-31-2	Pad	Ut	Fertilized	3	0.44 433 912	0.787 193 287	0	5	95	0	0	2	60	30	0	0
D63	D63.32	D63-32-1	Pad	MxHb	Fertilized	0	0.237 857 043	0.897 353 243	0	0	100	0	0	2	90	5	0	0
D63	D63.32	D63-32-2	Pad	MxHb	Fertilized	0	0.277 319 968	0.943 937 824	3	0	97	0	0	2	75	15	0	0
D63	D63.33	D63-33-1	Pad	MdHb	Fertilized	0	0.490 664 501	1.06 113 572	5	0	95	0	0	1	85	10	0	0
D63	D63.33	D63-33-2	Pad	MdHb	Fertilized	0	0.318 552 988	0.92 917 373	0	0	100	0	0	1	90	5	0	0
D63	D63.34	D63-34-1	Pad	Ut	Unfertilized	1	0.371 949 993	0.831 177 051	0	10	90	0	0	0	40	50	0	0
D63	D63.34	D63-34-2	Pad	Ut	Unfertilized	2.5	0.296 086 782	0.75 924 176	0	2	98	0	0	5	60	25	0	0
D63	D63.35	D63-35-1	Pad	MxHb	Fertilized	0	0.20 136 478	0.850 441 946	0	0	100	0	0	1	90	5	0	0
D63	D63.35	D63-35-2	Pad	MxHb	Fertilized	0	0.30 659 535	0.861 804 928	0	0	100	0	0	1	95	1	0	0
D63	D63.36	D63-36-1	Pad	MdHb	Unfertilized	0	0.570 463 126	1.004 230 529	12	4	83	0	0	4	65	2	0	0
D63	D63.36	D63-36-2	Pad	MdHb	Unfertilized	0	0.550 040 154	0.922 193 816	10	4	85	0	0	2	80	0.1	0	0
D63	D63.37	D63-37-1	Pad	Ut	Unfertilized	2	0.52 562 097	0.78 123 976	0	10	90	0	0	7	10	10	70	0
D63	D63.37	D63-37-2	Pad	Ut	Unfertilized	4	0.491 202 405	0.818 110 974	0	5	95	0	0	0	8	10	70	0
D63	D63.38	D63-38-1	Pad	Md	Unfertilized	0	0.481 865 211	0.943 258 257	7	0	93	0	0	1	3	10	80	0
D63	D63.38	D63-38-2	Pad	Md	Unfertilized	0	0.472 162 627	0.917 378 709	50	0	50	0	0	0	5	30	60	0
D63	D63.39	D63-39-1	Pad	Hb	Unfertilized	0.5	0.851 070 863	0.866 184 549	2	95	2	0	0	2	0.1	0	0	2

Table A2. (*continued*).

Site	Block	Trap	Area	Treatment	Fertilization	Organic matter depth (cm) — OMD	Light transmission index — PAR	Soil temperature index — Soil_T	Bare soil cover (%) — Bare	Litter material cover (%) — Litter	Total plant cover (%) — Plant	Coarse woody material cover (%) — CWM	Total overstory tree cover (%) — Tree	Total shrub cover (%) — Shrub	Total forb cover (%) — Forb	Total grass cover (%) — Grass	Total sedge cover (%) — Sedge	Total moss cover (%) — Moss
D63	D63.39	D63-39-2	Pad	Hb	Unfertilized	2.5	0.884 255 484	0.838 888 938	1	96	3	0	0	2	0.1	0	0	1
D63	D63.40	D63-40-1	Pad	Hb	Fertilized	1	0.853 883 081	0.855 206 041	2	97	1	0	0	1	0	0	0	0
D63	D63.40	D63-40-2	Pad	Hb	Fertilized	1	0.803 321 002	0.810 438 136	1	95	4	0	0	2	2	0	0	0
D63	D63.F1	D63-F1-1	For	For	Unfertilized	6.5	0.260 921 189	0.872 782 506	0	5	95	0	5	15	75	10	0	0
D63	D63.F1	D63-F1-2	For	For	Unfertilized	3.5	0.272 142 857	0.882 055 365	0	2	88	10	1	25	60	5	0	10
D63	D63.F1	D63-F1-3	For	For	Unfertilized	6.5	0.155 747 206	0.895 472 311	0.1	2	96	0.1	30	70	30	5	0	0
D63	D63.F1	D63-F1-4	For	For	Unfertilized	11.5	0.309 744 982	0.907 193 645	1	5	94	0.1	0.1	40	50	1	0	0
D63	D63.F1	D63-F1-5	For	For	Unfertilized	9	0.486 795 739	0.836 897 501	3	2	85	10	5	50	20	0	0	2
D63	D63.F1	D63-F1-6	For	For	Unfertilized	12.5	0.164 025 905	0.85 559 945	0.1	2	94	3	5	30	20	2	0	1
D63	D63.F1	D63-F1-7	For	For	Unfertilized	12	0.350 793 651	0.868 893 388	1	2	95	0.1	25	60	25	0.1	0	0.1
D63	D63.F1	D63-F1-8	For	For	Unfertilized	10	0.146 549 499	0.836 333 345	0.1	2	95	0.1	2	70	20	1	0	0
D63	D63.F2	D63-F2-1	For	For	Unfertilized	12	0.62 451 706	0.806 075 406	3	3	92	0.1	20	40	5	0.1	0	1
D63	D63.F2	D63-F2-2	For	For	Unfertilized	8	0.600 511 509	0.766 248 523	5	35	50	2	5	40	20	0.1	0	6
D63	D63.F2	D63-F2-3	For	For	Unfertilized	3	0.751 133 787	0.834 382 378	10	50	25	15	20	10	2	3	0	1
D63	D63.F2	D63-F2-4	For	For	Unfertilized	9	0.58 984 127	0.826 499 577	2	20	70	4	25	60	10	0.1	0	1
D63	D63.F2	D63-F2-5	For	For	Unfertilized	9.5	0.781 920 904	0.829 869 276	1	12	80	7	80	20	15	0.1	0	10
D63	D63.F2	D63-F2-6	For	For	Unfertilized	12	0.364 906 178	0.831 954 957	0.1	1	92	6	5	70	15	0.1	0	10
D63	D63.F2	D63-F2-7	For	For	Unfertilized	9	0.397 777 778	0.808 911 222	0.1	5	90	5	80	80	10	0.1	0	10
D63	D63.F2	D63-F2-8	For	For	Unfertilized	8.5	0.370 322 433	0.822 094 029	1	3	95	0.1	0	80	15	0.1	0	0.1
J10	J10.01	J10-01-1	Pad	Md	Unfertilized	0	0.876 897 504	0.826 867 854	20	0.1	60	0	0	1	6	55	0.1	2
J10	J10.01	J10-01-2	Pad	Md	Unfertilized	0	1.024 286 508	0.81 085 481	25	0.1	75	0	0	1	30	45	0.1	0.1
J10	J10.02	J10-02-1	Pad	Md	Fertilized	0	0.895 608 351	0.772 268 533	25	0.1	50	0	0	1	25	20	0.1	3
J10	J10.02	J10-02-2	Pad	Md	Fertilized	0	0.673 853 866	0.848 139 569	25	0.1	75	0	0	0.1	40	35	0.1	0
J10	J10.03	J10-03-1	Pad	Ut	Unfertilized	2.5	0.737 505 767	0.765 398 492	0	20	80	0	0	0	30	50	0.1	5
J10	J10.03	J10-03-2	Pad	Ut	Unfertilized	3.8	0.639 798 958	0.854 935 501	0	15	85	0	0	0	7	80	0.1	0
J10	J10.04	J10-04-1	Pad	MxHb	Fertilized	1.1	0.904 441 352	0.755 558 696	90	5	0.1	0	0	0	0.1	0	0	0
J10	J10.04	J10-04-2	Pad	MxHb	Fertilized	0	0.995 440 908	0.796 491 329	90	0.1	10	2	0	0	10	0.1	0	1
J10	J10.05	J10-05-1	Pad	MdHb	Fertilized	0	1.106 005 759	0.875 702 526	50	0.1	50	0	0	0	48	2	0	0
J10	J10.05	J10-05-2	Pad	MdHb	Fertilized	0	1.170 630 783	0.767 020 918	90	0.1	10	0	0	0	6	4	0	0.1
J10	J10.06	J10-06-1	Pad	Hb	Fertilized	2.5	0.8 686 933	0.765 868 466	0.1	95	5	0	0	1	2	0	0	3
J10	J10.06	J10-06-2	Pad	Hb	Fertilized	2.7	0.893 394 219	0.751 583 853	0	98	2	0	0	1	1	0	0	1
J10	J10.07	J10-07-1	Pad	Ut	Unfertilized	2.9	0.663 308 385	0.813 938 086	0	10	90	0	0	0	80	10	0.1	0.1
J10	J10.07	J10-07-2	Pad	Ut	Unfertilized	3.1	0.794 920 691	0.76 668 098	1	20	80	0	0	0	30	50	0.1	0
J10	J10.08	J10-08-1	Pad	Hb	Unfertilized	2.4	0.909 485 367	0.923 141 223	0.1	92	8	0	0	1	2	0	0	5
J10	J10.08	J10-08-2	Pad	Hb	Unfertilized	2.2	0.837 596 896	0.721 585 649	0	93	7	0	0	2	5	0	0	0
J10	J10.09	J10-09-1	Pad	Md	Unfertilized	0	0.782 995 175	0.978 011 693	30	0.1	70	0	0	1	60	10	0.1	0
J10	J10.09	J10-09-2	Pad	Md	Unfertilized	0	0.847 782 911	0.695 285 395	15	0	85	0	0	0	75	10	0.1	0

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Table A2. (*continued*).

Site	Block	Trap	Area	Treatment	Fertilization	Organic matter depth (cm) — OMD	Light transmission index — PAR	Soil temperature index — Soil_T	Bare soil cover (%) — Bare	Litter material cover (%) — Litter	Total plant cover (%) — Plant	Coarse woody material cover (%) — CWM	Total overstory tree cover (%) — Tree	Total shrub cover (%) — Shrub	Total forb cover (%) — Forb	Total grass cover (%) — Grass	Total sedge cover (%) — Sedge	Total moss cover (%) — Moss
J10	J10.10	J10-10-1	Pad	Hb	Fertilized	3.1	0.751 796 755	0.751 794 833	0	90	17	0	0	2	0.1	0.1	0	15
J10	J10.10	J10-10-2	Pad	Hb	Fertilized	1.9	0.804 287 263	0.747 092 797	0	93	3	0	0	2	0	0.1	0	2
J10	J10.11	J10-11-1	Pad	MdHb	Unfertilized	0	0.971 520 826	0.840 325 392	90	8	12	0	0	2	10	2	0.1	0
J10	J10.11	J10-11-2	Pad	MdHb	Unfertilized	0	1.096 209 955	0.770 338 719	73	2	25	0	0	3	20	2	0.1	0
J10	J10.12	J10-12-1	Pad	Ut	Fertilized	0	0.503 457 862	0.70 364 806	0	15	85	0	0	1	50	35	0.1	0
J10	J10.12	J10-12-2	Pad	Ut	Fertilized	3.6	0.676 037 242	0.773 639 939	0	20	80	0	0	1	40	40	0.1	2
J10	J10.13	J10-13-1	Pad	MdHb	Fertilized	0	0.881 767 413	0.801 890 091	90	0.1	9	0	0	1	5	5	0.1	1
J10	J10.13	J10-13-2	Pad	MdHb	Fertilized	0	1.062 237 074	0.725 584 103	80	1	17	1	0	2	15	3	0.1	0
J10	J10.14	J10-14-1	Pad	Md	Unfertilized	0	0.68 053 004	0.877 702 777	5	0	95	0	0	0	50	45	0	0.1
J10	J10.14	J10-14-2	Pad	Md	Unfertilized	0	0.991 293 652	0.815 493 832	5	0	95	0	0	0	20	65	0	0.1
J10	J10.15	J10-15-1	Pad	MdHb	Fertilized	0	0.95 033 545	1.054 443 352	80	0	20	0	0	1	80	0.1	0.1	0
J10	J10.15	J10-15-2	Pad	MdHb	Fertilized	0	1.039 759 998	0.73 051 971	80	0.1	20	0	0	1	17	3	0.1	0
J10	J10.16	J10-16-1	Pad	Ut	Fertilized	3.2	0.737 198 825	1.016 543 487	0	10	90	0	0	1	50	40	0.1	10
J10	J10.16	J10-16-2	Pad	Ut	Fertilized	0	0.766 426 669	0.776 864 483	0	15	85	0	0	0	40	35	0.1	5
J10	J10.17	J10-17-1	Pad	MxHb	Fertilized	0	0.980 566 182	0.847 620 838	85	0.1	15	0	0	0	15	0	0	0
J10	J10.17	J10-17-2	Pad	MxHb	Fertilized	0	1.058 694 128	0.842 899 276	90	0.1	10	0	0	2	10	10	0	0
J10	J10.18	J10-18-1	Pad	MdHb	Unfertilized	0	0.890 610 741	0.800 755 971	65	5	30	0	0	0.1	20	10	0.1	2
J10	J10.18	J10-18-2	Pad	MdHb	Unfertilized	0	0.968 288 271	0.812 259 479	75	0.1	25	0	0	1	15	10	0.1	0.1
J10	J10.19	J10-19-1	Pad	MxHb	Unfertilized	0.9	0.64 755 089	0.911 907 633	75	0.1	25	0	0	0	25	0	0	0
J10	J10.19	J10-19-2	Pad	MxHb	Unfertilized	0	1.057 701 824	0.875 120 729	80	0.1	20	0	0	1	20	0.1	0	0
J10	J10.20	J10-20-1	Pad	Md	Fertilized	0	0.735 193 288	1.133 728 052	4	0.1	95	0	0	1	65	30	0.1	0.1
J10	J10.20	J10-20-2	Pad	Md	Fertilized	0	0.974 920 754	0.832 733 232	9	0.1	90	0	0	1	60	30	0.1	0
J10	J10.21	J10-21-1	Pad	MxHb	Unfertilized	0	1.063 442 358	0.828 003 993	95	0.1	5	0.1	0	1	4	0	0	0.1
J10	J10.21	J10-21-2	Pad	MxHb	Unfertilized	0	1.07 301 308	0.879 092 455	97	0.1	3	0	0	1	2	0	0	0.1
J10	J10.22	J10-22-1	Pad	Ut	Unfertilized	1.8	0.801 420 655	0.709 955 313	0.1	20	80	0	0	2	1	79	0.1	0.1
J10	J10.22	J10-22-2	Pad	Ut	Unfertilized	2	0.620 764 926	0.653 783 669	0	10	90	0	0	0	4	85	5	0
J10	J10.23	J10-23-1	Pad	Hb	Unfertilized	3.3	0.79 631 334	0.719 247 981	0	98	2	0	0	2	0	0	0	0
J10	J10.23	J10-23-2	Pad	Hb	Unfertilized	2.7	0.944 460 486	0.733 279 182	0	98	2	0	0	1	1	0.1	0	0
J10	J10.24	J10-24-1	Pad	MxHb	Fertilized	0	0.995 011 283	0.830 356 461	99	0.1	1	0	0	1	1	0	0	0
J10	J10.24	J10-24-2	Pad	MxHb	Fertilized	1	0.793 114 631	0.8 057 587	95	0.1	5	0	0	0	0	0	0	5
J10	J10.25	J10-25-1	Pad	Ut	Fertilized	1.4	0.63 248 467	0.758 795 009	0	20	80	0	0	0	7	73	0.1	0.1
J10	J10.25	J10-25-2	Pad	Ut	Fertilized	2.8	0.811 468 526	0.747 448 825	0.1	20	80	0	0	0	25	55	0.1	2
J10	J10.26	J10-26-1	Pad	MxHb	Unfertilized	0	1.028 346 352	0.864 131 046	98	0.1	2	0	0	1	1	0	0	2
J10	J10.26	J10-26-2	Pad	MxHb	Unfertilized	0.9	0.958 669 621	0.975 762 527	100	0.1	0	0	0	0	0	0	0	0.1

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Table A2. (*continued*).

Site	Block	Trap	Area	Treatment	Fertilization	Organic matter depth (cm) — OMD	Light transmission index — PAR	Soil temperature index — Soil_T	Bare soil cover (%) — Bare	Litter material cover (%) — Litter	Total plant cover (%) — Plant	Coarse woody material cover (%) — CWM	Total overstory tree cover (%) — Tree	Total shrub cover (%) — Shrub	Total forb cover (%) — Forb	Total grass cover (%) — Grass	Total sedge cover (%) — Sedge	Total moss cover (%) — Moss
J10	J10.27	J10-27-1	Pad	Ut	Unfertilized	2	0.760 934 857	0.749 369 985	0.1	10	90	0	0	0	50	40	0.1	2
J10	J10.27	J10-27-2	Pad	Ut	Unfertilized	3.2	0.648 156 766	0.802 871 984	0	15	85	0	0	0	35	50	0.1	0.1
J10	J10.28	J10-28-1	Pad	Hb	Fertilized	1.7	0.851 085 292	0.76 982 413	0	97	3	0	0	2	1	0	0	0
J10	J10.28	J10-28-2	Pad	Hb	Fertilized	3.4	0.783 680 783	0.761 665 011	0	96	4	0	0	2	2	0	0	0
J10	J10.29	J10-29-1	Pad	Md	Fertilized	0	0.752 046 873	0.812 464 841	20	0.1	80	0	0	0	50	30	0.1	5
J10	J10.29	J10-29-2	Pad	Md	Fertilized	0	0.941 078 597	0.778 621 427	20	0.1	80	0	0	1	30	50	0.1	0
J10	J10.30	J10-30-1	Pad	Ut	Fertilized	3.8	0.795 819 292	0.773 053 861	0	30	70	0	0	0	8	62	0.1	1
J10	J10.30	J10-30-2	Pad	Ut	Fertilized	2.8	0.775 347 533	0.778 983 954	0	20	80	0	0	0	30	50	0.1	15
J10	J10.31	J10-31-1	Pad	MdHb	Unfertilized	0	1.064 663 947	1.062 283 484	99	0.1	1	0	0	0.1	10	0	0	0
J10	J10.31	J10-31-2	Pad	MdHb	Unfertilized	0	1.076 844 585	0.91 174 259	99	0.1	1	0	0	1	0	0	0	1
J10	J10.32	J10-32-1	Pad	MxHb	Fertilized	0	1.0 627 268	0.940 169 198	95	0.1	5	0	0	0	2	0	0	3
J10	J10.32	J10-32-2	Pad	MxHb	Fertilized	0	1.026 279 332	0.914 649 152	97	0.1	3	0	0	1	1	0	0	1
J10	J10.33	J10-33-1	Pad	MdHb	Fertilized	0	0.979 884 254	0.923 290 376	93	5	2	0	0	0.1	2	0	0	0.1
J10	J10.33	J10-33-2	Pad	MdHb	Fertilized	0	1.023 925 632	0.743 709 702	83	2	15	0	0	0.1	12	3	1	0
J10	J10.34	J10-34-1	Pad	MdHb	Unfertilized	0	0.913 401 533	0.891 307 859	85	0.1	15	0	0	1	13	2	0.1	0
J10	J10.34	J10-34-2	Pad	MdHb	Unfertilized	0	0.997 743 676	0.872 724 919	92	0.1	8	0.1	0	1	8	0.1	0.1	0
J10	J10.35	J10-35-1	Pad	Md	Fertilized	0	1.01 704 194	0.901 550 594	10	10	80	0	0	2	42	30	0.1	8
J10	J10.35	J10-35-2	Pad	Md	Fertilized	0	0.972 544 982	0.88 938 825	15	5	80	0	0	0	45	30	0.1	5
J10	J10.36	J10-36-1	Pad	Hb	Unfertilized	1.6	0.923 309 143	0.7 941 511	0	97	3	0	0	2	1	0	0	0
J10	J10.36	J10-36-2	Pad	Hb	Unfertilized	4.1	0.752 407 191	0.78 461 792	0	98	2	0	0	1	0.1	0	0	0
J10	J10.37	J10-37-1	Pad	Hb	Fertilized	1.2	0.88 539 654	0.788 201 979	0	96	4	0	0	2	0	0	0	2
J10	J10.37	J10-37-2	Pad	Hb	Fertilized	4.1	1.039 179 009	0.784 992 436	0	98	2	0	0	1	1	0	1	1
J10	J10.38	J10-38-1	Pad	MxHb	Unfertilized	0.9	0.994 746 384	0.724 694 009	80	0.1	20	0	0	0	0	0	0	0
J10	J10.38	J10-38-2	Pad	MxHb	Unfertilized	0	0.798 309 891	0.818 036 549	70	0.1	30	0	0	1	20	0	0	0
J10	J10.39	J10-39-1	Pad	Md	Unfertilized	0	0.753 038 922	0.738 520 718	50	0	95	0	0	1	30	55	0.1	0
J10	J10.39	J10-39-2	Pad	Md	Unfertilized	0	0.677 050 756	0.855 804 274	15	0	85	0	0	2	40	35	0.1	0
J10	J10.40	J10-40-1	Pad	Hb	Unfertilized	1.9	0.905 412 969	0.751 255 686	0	97	3	0	0	1	50	1	0	1
J10	J10.40	J10-40-2	Pad	Hb	Unfertilized	1.7	0.969 522 971	0.826 821 085	0	92	6	0	0	1	1	0	0	4
J10	J10.F1	J10-F1-1	For	For	Unfertilized	6.6	0.741 226 987	0.756 401 574	0.1	70	30	1	50	3	30	0	0	10
J10	J10.F1	J10-F1-2	For	For	Unfertilized	4.4	0.741 563 773	0.783 864 024	0.1	25	75	2	40	4	5	0.1	0	75
J10	J10.F1	J10-F1-3	For	For	Unfertilized	6.1	0.859 892 799	0.762 894 288	0	5	95	2	40	0.1	1	0	0	95
J10	J10.F1	J10-F1-4	For	For	Unfertilized	9.1	0.585 785 709	0.775 094 596	0	70	30	3	10	0	0.1	0	0	30
J10	J10.F1	J10-F1-5	For	For	Unfertilized	4.5	1.104 364 327	0.844 429 687	0	55	45	0	40	3	5	0	0	40
J10	J10.F1	J10-F1-6	For	For	Unfertilized	8.1	1.819 848 901	0.873 479 023	0	10	90	1	30	0	0	0	0	90
J10	J10.F1	J10-F1-7	For	For	Unfertilized	4.9	0.837 211 477	0.772 667 923	0	0.1	100	0	40	10	10	1	0	100
J10	J10.F1	J10-F1-8	For	For	Unfertilized	8.1	0.895 350 783	0.844 607 843	0.1	40	60	7	20	15	7	1	0	15
J10	J10.F2	J10-F2-1	For	For	Unfertilized	9.8	0.692 763 016	0.795 861 185	0.1	15	70	15	20	15	45	1	0	20

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Table A2. (*continued*).

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J10	J10.F2	J10-F2-2	For	For	Unfertilized	12.8	0.85 182 834	0.836 948 606	1	60	40	0	25	4	30	1	0	15
J10	J10.F2	J10-F2-3	For	For	Unfertilized	10.1	1.02 109 887	0.83 686 612	0	40	50	10	60	5	30	0.1	0	10
J10	J10.F2	J10-F2-4	For	For	Unfertilized	11.5	0.861 995 614	0.837 489 323	0.1	60	40	2	80	3	35	0	0	0.1
J10	J10.F2	J10-F2-5	For	For	Unfertilized	9.1	0.814 914 406	0.781 995 722	2	58	40	1	60	15	30	0.1	0	0.1
J10	J10.F2	J10-F2-6	For	For	Unfertilized	15.6	0.97 798 888	0.712 310 199	0	30	70	0.1	50	50	20	0.1	0	1
J10	J10.F2	J10-F2-7	For	For	Unfertilized	7.4	0.824 072 239	0.765 173 286	0	5	95	4	20	10	4	1	0	90
J10	J10.F2	J10-F2-8	For	For	Unfertilized	9.7	0.739 511 064	0.853 155 123	0	70	30	8	45	30	10	0.1	0	10
P3	P3.01	P3-01-1	Pad	Md	Unfertilized	0	0.698 774 294	0.984 964 484	5	0.1	95	0	0	1	87	5	1	1
P3	P3.01	P3-01-2	Pad	Md	Unfertilized	0	0.537 362 396	0.874 256 432	5	0	95	0	0	0	85	10	1	0
P3	P3.02	P3-02-1	Pad	Ut	Fertilized	1.3	0.797 727 686	1.03 577 114	0	1	100	0	0	0.1	5	93	1	1
P3	P3.02	P3-02-2	Pad	Ut	Fertilized	2.3	0.678 116 194	0.876 265 831	0	1	100	0	0	0.1	40	50	1	2
P3	P3.03	P3-03-1	Pad	MxHb	Fertilized	0	0.990 888 932	0.932 591 359	65	0.1	45	0	0	0	44	1	1	0
P3	P3.03	P3-03-2	Pad	MxHb	Fertilized	0	0.920 437 783	0.896 021 856	70	0.1	30	0	0	0	29	1	0	0
P3	P3.04	P3-04-1	Pad	MxHb	Unfertilized	0	0.954 617 399	1.005 345 199	75	0.1	25	0	0	0	24	1	0.1	0.1
P3	P3.04	P3-04-2	Pad	MxHb	Unfertilized	0	3.143 131 274	0.855 870 719	60	0.1	40	0	0	0	39	0.1	0.1	0.1
P3	P3.05	P3-05-1	Pad	MdHb	Fertilized	0	1.045 154 953	0.970 398 595	99	1	1	0.1	0	1	0.1	0	0	0
P3	P3.05	P3-05-2	Pad	MdHb	Fertilized	0	0.860 090 529	0.8 487 221	75	0.1	25	0.1	0	0.1	25	0.1	0	0
P3	P3.06	P3-06-1	Pad	Md	Unfertilized	0	0.566 880 882	0.864 486 208	1	0.1	99	0	0	1	70	30	1	0
P3	P3.06	P3-06-2	Pad	Md	Unfertilized	0	0.532 604 035	0.910 119 576	0.1	0.1	99	0	0	1	25	75	0.1	0.1
P3	P3.07	P3-07-1	Pad	Hb	Unfertilized	2.3	0.797 674 875	0.929 288 495	0	95	5	0	0	1	3	4	1	1
P3	P3.07	P3-07-2	Pad	Hb	Unfertilized	2.6	0.919 943 227	0.919 186 402	0	99	2	0	0	1	1	0.1	0.1	0
P3	P3.08	P3-08-1	Pad	Hb	Fertilized	2.3	0.831 955 188	0.737 559 632	0.1	90	25	0	0	2	23	1	0.1	0.1
P3	P3.08	P3-08-2	Pad	Hb	Fertilized	1.1	0.673 964 525	0.761 765 521	0	80	25	0	0	2	22	3	0.1	0.1
P3	P3.09	P3-09-1	Pad	Md	Fertilized	0	0.529 600 095	0.893 562 306	0.1	0	100	0	0	2	80	15	5	0.1
P3	P3.09	P3-09-2	Pad	Md	Fertilized	0	0.698 796 179	0.899 430 462	5	0.1	95	0	0	2	70	20	5	0.1
P3	P3.10	P3-10-1	Pad	Ut	Unfertilized	4.2	0.492 864 771	0.810 541 681	0.1	5	95	0	0	0	15	70	5	2
P3	P3.10	P3-10-2	Pad	Ut	Unfertilized	2.5	0.732 499 363	0.729 859 357	0	20	80	0	0	1	15	60	5	2
P3	P3.11	P3-11-1	Pad	Md	Fertilized	0	0.699 962 384	0.870 349 058	3	0.1	95	0	0	2	85	5	3	0
P3	P3.11	P3-11-2	Pad	Md	Fertilized	0	0.61 939 438	0.893 497 085	2	0	98	0	0	1	80	15	3	0
P3	P3.12	P3-12-1	Pad	MdHb	Unfertilized	0	0.959 698 564	0.864 483 986	85	0.1	15	0.1	0	2	13	3	0.1	0
P3	P3.12	P3-12-2	Pad	MdHb	Unfertilized	0	0.828 632 459	0.880 002 926	70	0	30	0	0	2	25	2	3	0
P3	P3.13	P3-13-1	Pad	Hb	Fertilized	2	0.769 399 069	0.855 311 016	0	50	40	0	0	0	35	3	2	0
P3	P3.13	P3-13-2	Pad	Hb	Fertilized	3	0.764 623 177	0.810 180 266	3	95	4	0	0	1	4	0.1	0	0

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Table A2. (*continued*).

Site	Block	Trap	Area	Treatment	Fertilization	Organic matter depth (cm) — OMD	Light transmission index — PAR	Soil temperature index — Soil_T	Bare soil cover (%) — Bare	Litter material cover (%) — Litter	Total plant cover (%) — Plant	Coarse woody material cover (%) — CWM	Total overstory tree cover (%) — Tree	Total shrub cover (%) — Shrub	Total forb cover (%) — Forb	Total grass cover (%) — Grass	Total sedge cover (%) — Sedge	Total moss cover (%) — Moss
P3	P3.14	P3-14-1	Pad	Hb	Unfertilized	1.3	0.593 546 392	0.772 717 872	0	95	1	0	0	1	1	0.1	0	0
P3	P3.14	P3-14-2	Pad	Hb	Unfertilized	1.1	0.742 610 567	0.778 839 647	4	95	2	0	0	2	0.1	0	0	2
P3	P3.15	P3-15-1	Pad	MdHb	Unfertilized	0	0.765 287 706	0.889 931 489	60	0	40	0	0	2	25	10	5	0
P3	P3.15	P3-15-2	Pad	MdHb	Unfertilized	0	0.863 027 591	0.949 683 809	70	0	30	0	0	2	25	5	0.1	0
P3	P3.16	P3-16-1	Pad	MxHb	Unfertilized	0	0.981 737 314	0.866 281 996	75	0.1	25	0	0	1	24	1	0	0.1
P3	P3.16	P3-16-2	Pad	MxHb	Unfertilized	0	0.963 378 105	0.961 317 468	80	0.1	20	0	0	0	15	0	0	5
P3	P3.17	P3-17-1	Pad	Hb	Unfertilized	2.5	0.862 684 859	0.826 645 951	0	98	3	0	0	1	0	0	0	2
P3	P3.17	P3-17-2	Pad	Hb	Unfertilized	0	0.726 684 088	0.810 498 775	0	99	1	0	0	1	0	0	0.1	0
P3	P3.18	P3-18-1	Pad	Ut	Unfertilized	7.2	0.62 704 176	0.806 225 354	0	40	60	0	0	1	30	30	0.1	0.1
P3	P3.18	P3-18-2	Pad	Ut	Unfertilized	5.8	0.703 537 688	0.732 717 686	0	20	80	0	0	0	45	35	2	2
P3	P3.19	P3-19-1	Pad	MdHb	Unfertilized	0	1.041 551 901	0.899 730 256	75	0.1	25	0	0	1	23	0.1	0.1	0
P3	P3.19	P3-19-2	Pad	MdHb	Unfertilized	3.1	0.91 611 993	0.871 154 913	90	1	6	0	0	0.1	5	1	2	0
P3	P3.20	P3-20-1	Pad	Md	Fertilized	0	0.621 624 077	0.865 028 245	3	5	92	0	0	1	55	35	0.1	0
P3	P3.20	P3-20-2	Pad	Md	Fertilized	0	0.623 470 452	0.926 306 057	4	0.1	95	0	0	1	60	35	5	0
P3	P3.21	P3-21-1	Pad	Ut	Unfertilized	3.7	0.591 969 556	0.803 749 415	0	5	95	0	0	1	65	25	0.1	0
P3	P3.21	P3-21-2	Pad	Ut	Unfertilized	2.5	0.68 781 725	0.835 141 035	0	30	70	0	0	0	50	20	0	0
P3	P3.22	P3-22-1	Pad	MxHb	Unfertilized	0	0.937 403 915	0.894 665 279	90	5	5	0	0	0	5	0	2	0.1
P3	P3.22	P3-22-2	Pad	MxHb	Unfertilized	0	0.728 806 868	0.917 486 134	30	0.1	70	0	0	0	60	8	12	0
P3	P3.23	P3-23-1	Pad	MdHb	Fertilized	0	0.961 484 302	0.884 083 718	80	1	20	0	0	0.1	5	3	0.1	0
P3	P3.23	P3-23-2	Pad	MdHb	Fertilized	0	0.977 595 321	0.899 707 411	96	0.1	4	0	0	1	4	0.1	5	0
P3	P3.24	P3-24-1	Pad	Md	Unfertilized	0	0.46 802 175	0.889 953 284	0	0.1	100	0	0	0	40	55	0.1	0
P3	P3.24	P3-24-2	Pad	Md	Unfertilized	0	0.763 520 375	0.789 169 599	1	1	98	0	0	1	80	18	0	0.1
P3	P3.25	P3-25-1	Pad	Hb	Fertilized	1.1	1.011 229 013	0.841 311 844	0	100	1	0	0	1	0.1	0	0	0
P3	P3.25	P3-25-2	Pad	Hb	Fertilized	1.8	0.81 419 727	0.816 997 009	0	95	5	0	0	1	5	0	0.1	0
P3	P3.26	P3-26-1	Pad	Ut	Fertilized	3.3	0.774 009 288	0.811 888 167	0	15	85	0	0	1	60	25	0.1	0.1
P3	P3.26	P3-26-2	Pad	Ut	Fertilized	2.3	0.648 732 141	0.838 415 598	0	20	80	0	0	1	55	25	0.1	0.1
P3	P3.27	P3-27-1	Pad	Ut	Unfertilized	1.8	0.721 072 384	0.726 661 849	0	5	95	0	0	2	75	15	0.1	0.1
P3	P3.27	P3-27-2	Pad	Ut	Unfertilized	2.4	0.671 812 606	0.735 458 636	0.1	10	90	0	0	3	85	10	2	0.1
P3	P3.28	P3-28-1	Pad	Md	Fertilized	0	0.699 183 188	0.844 313 458	5	0.1	95	0	0	1	75	20	0.1	1
P3	P3.28	P3-28-2	Pad	Md	Fertilized	0	0.705 876 219	0.954 703 717	20	0.1	80	0	0	1	70	10	0.1	0
P3	P3.29	P3-29-1	Pad	Ut	Fertilized	2.6	0.649 255 683	0.714 900 189	1	15	85	0	0	0	65	20	0.1	0.1
P3	P3.29	P3-29-2	Pad	Ut	Fertilized	3.4	0.718 123 898	0.716 381 242	0.1	15	85	0	0	1	55	30	5	0.1
P3	P3.30	P3-30-1	Pad	Md	Unfertilized	0	0.771 513 508	0.857 810 351	20	0.1	80	0	0	1	60	15	5	0
P3	P3.30	P3-30-2	Pad	Md	Unfertilized	0	0.811 647 466	0.856 698 585	20	0.1	80	0	0	1	60	15	0.1	0

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Table A2. (*concluded*).

Site	Block	Trap	Area	Treatment	Fertilization	Organic matter depth (cm) — OMD	Light transmission index — PAR	Soil temperature index — Soil_T	Bare soil cover (%) — Bare	Litter material cover (%) — Litter	Total plant cover (%) — Plant	Coarse woody material cover (%) — CWM	Total overstory tree cover (%) — Tree	Total shrub cover (%) — Shrub	Total forb cover (%) — Forb	Total grass cover (%) — Grass	Total sedge cover (%) — Sedge	Total moss cover (%) — Moss
P3	P3.31	P3-31-1	Pad	MxHb	Fertilized	0	0.959 924 749	0.813 539 147	15	0.1	85	0	0	1	80	5	5	0
P3	P3.31	P3-31-2	Pad	MxHb	Fertilized	0	0.93 291 504	0.924 530 214	5	0.1	95	0	0	0	80	10	10	0
P3	P3.32	P3-32-1	Pad	MdHb	Unfertilized	0	0.927 291 496	0.99 172 388	70	1	30	0	0	0	15	5	0.1	0
P3	P3.32	P3-32-2	Pad	MdHb	Unfertilized	0	0.905 572 528	0.880 239 358	50	1	50	0	0	1	40	10	2	0
P3	P3.33	P3-33-1	Pad	Hb	Fertilized	2.1	0.756 866 726	0.785 213 558	1	80	20	0	0	2	15	3	0.1	1
P3	P3.33	P3-33-2	Pad	Hb	Fertilized	3.6	0.784 112 824	0.843 888 256	0.1	60	40	0	0	1	30	10	0.1	0
P3	P3.34	P3-34-1	Pad	MxHb	Unfertilized	0	0.914 835 335	0.921 785 277	50	0.1	50	0	0	1	45	5	0.1	0
P3	P3.34	P3-34-2	Pad	MxHb	Unfertilized	0	0.760 918 463	0.851 914 745	65	0.1	35	0	0	0	35	0.1	0	0
P3	P3.35	P3-35-1	Pad	MdHb	Fertilized	0	0.936 220 842	0.971 832 399	93	0.1	7	0	0	2	5	0	0.1	0
P3	P3.35	P3-35-2	Pad	MdHb	Fertilized	0	0.853 648 682	1.126 000 775	80	0.1	20	0	0	1	15	5	20	0
P3	P3.36	P3-36-1	Pad	Ut	Fertilized	2.1	0.753 616 688	0.808 805 797	0.1	25	75	0	0	1	15	40	15	0.1
P3	P3.36	P3-36-2	Pad	Ut	Fertilized	3.6	0.751 152 349	0.732 875 751	0.1	30	70	0	0	1	15	40	0.1	1
P3	P3.37	P3-37-1	Pad	MdHb	Fertilized	0	0.948 077 461	0.975 958 051	80	0.1	20	0	0	0	15	5	0.1	0
P3	P3.37	P3-37-2	Pad	MdHb	Fertilized	0	0.943 361 144	0.950 116 651	75	0.1	25	0.1	0	0	20	5	0.1	2
P3	P3.38	P3-38-1	Pad	MxHb	Fertilized	0	0.789 602 006	0.914 116 155	25	1	75	0	0	1	70	5	1	0
P3	P3.38	P3-38-2	Pad	MxHb	Fertilized	0	0.926 920 207	3.010 439 788	60	0.1	40	0	0	2	37	2	0	0.1
P3	P3.39	P3-39-1	Pad	Hb	Unfertilized	1.8	0.646 971 376	0.781 698 108	20	92	80	0	0	1	8	0	0	1
P3	P3.39	P3-39-2	Pad	Hb	Unfertilized	3.1	0.860 839 795	0.541 808 279	1	96	3	0	0	1	3	0	0.1	0
P3	P3.40	P3-40-1	Pad	MxHb	Fertilized	0	0.925 981 182	0.935 112 923	70	0.1	30	0	0	0	28	2	2	0
P3	P3.40	P3-40-2	Pad	MxHb	Fertilized	0	0.938 995 859	0.927 594 307	70	0.1	30	0	0	1	27	1	0	0
P3	P3.F1	P3-F1-1	For	For	Unfertilized	3.8	0.99 623 845	0.542 891 054	0.1	1	99	4	25	2	30	0	0	80
P3	P3.F1	P3-F1-2	For	For	Unfertilized	3.6	0.831 388 701	0.61 830 738	1	2	98	1	20	4	10	0.1	0	95
P3	P3.F1	P3-F1-3	For	For	Unfertilized	5.1	0.826 450 626	0.517 770 806	0	0.1	95	5	0.1	1	13	0.1	0	95
P3	P3.F1	P3-F1-4	For	For	Unfertilized	7.5	0.975 944 037	0.61 235 211	0	0.1	90	10	10	7	9	0	0.1	90
P3	P3.F1	P3-F1-5	For	For	Unfertilized	6.9	1.053 796 192	0.543 099 896	0	0.1	100	1	0.1	0	0	0	0	100
P3	P3.F1	P3-F1-6	For	For	Unfertilized	11.4	0.961 774 728	0.967 894 621	0.1	1	95	5	25	0	0	0	0	95
P3	P3.F1	P3-F1-7	For	For	Unfertilized	11.6	1.182 442 894	0.784 601 654	0	0	100	0.1	25	14	0	0	4	100
P3	P3.F1	P3-F1-8	For	For	Unfertilized	8.6	0.797 032 405	0.648 481 319	1	0.1	90	10	20	3	0	0.1	0	90
P3	P3.F2	P3-F2-1	For	For	Unfertilized	9.1	0.911 435 456	0.706 530 026	0.1	80	40	0.1	80	2	10	2	0	20
P3	P3.F2	P3-F2-2	For	For	Unfertilized	13.1	0.748 798 533	0.775 977 118	5	30	6	25	10	0	6	0	0	3
P3	P3.F2	P3-F2-3	For	For	Unfertilized	6.1	0.71 651 867	0.675 292 696	0	0.1	100	5	20	30	20	0.1	0	100
P3	P3.F2	P3-F2-4	For	For	Unfertilized	12.6	1.288 554 518	0.704 592 192	0.1	5	90	2	25	14	25	4	0	70
P3	P3.F2	P3-F2-5	For	For	Unfertilized	5.1	0.868 671 292	0.623 603 958	0.1	60	40	7	30	25	0.1	0.1	0	3
P3	P3.F2	P3-F2-6	For	For	Unfertilized	14.6	0.817 486 849	0.691 305 225	0.1	5	95	0	60	30	50	5	2	15
P3	P3.F2	P3-F2-7	For	For	Unfertilized	13	0.792 093 014	0.699 813 324	0	5	95	0	60	20	5	1	0	90
P3	P3.F2	P3-F2-8	For	For	Unfertilized	5.7	0.810 675 774	0.760 261 129	0	0.1	100	0	0	25	5	5	0	100

*For, forest; Ut, untreated; Hb, herbicide; Md, mounding; MdHb, mounding + herbicide; MxHb, mixing + herbicide.

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