Oikos **OIK-04208**

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Appendix 1.

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Material and Methods:

Forest biota: We defined the seven biotic assemblages as follows: 1) Shrubs: any woody stem over 1 cm diameter at 30 cm height that was not of a tree species that had potential to reach the canopy, 2) Herbs: all herbaceous vegetation except graminoids but including trailing shrubs or low-growing plants with a woody rootstock, 3) Bryophytes: all mosses and liverworts, 4) Regenerating trees (saplings): individuals of any tree species with 1 to 5 cm diameter at 30 cm height, 5) Ground-beetles (carabids): Coleoptera in the Family Carabidae, 6) Spiders: arachnids in the Order Araneae, and 7) Songbirds: diurnal songbirds (Order: Passeriformes) with territory sizes smaller than 10 ha (this excluded corvid species that had territories larger than the size of an average EMEND compartment). A list of taxa belonging to each assemblage is provided in supplementary material (Appendix 1 Table A1). These taxa were sampled as described below.

Epigaeic arthropods: Arthropods (ground-beetles and spiders) were collected using un-baited pitfall traps (Spence and Niemelä 1994) deployed as described by (Work et al. 2010) and (Pinzon et al. 2016) in the post-harvest surveys of 2000, 2004 and 2009. Because the EMEND plots had not yet been established at the start of the 1998 season, pre-harvest arthropod assemblages were assessed as above but in 12 composite forest polygons grouping the 24 stands selected in 1997 from Alberta Vegetation Inventory (AVI) map. These stands represented pre-harvest condition for all three replicates of the four EMEND cover types, and they were subsequently partitioned by harvest treatments into the different EMEND compartments (see: Work et al. 2004, Work et al. 2010). Pitfall trap catches were standardized by number of effective trapping days within each compartment to eliminate potential biases caused by trap disturbance (e.g., Bergeron et al. 2013). Because most of the 12 pre-harvest transects crossed two or three compartments, we calculated the average basal area of each tree species in all compartments

crossed by a sampling transect in order to quantify the pre-harvest relation between arthropods and tree basal area.

Understory vegetation: Abundances of shrubs and regenerating trees (saplings) were assessed in the 600 aforementioned tree plots using a 2 × 10 m subplot at each end of each plot in 1998, 2001, 2004, and 2010. All shrub stems > 1 cm diameter at 30 cm height and tree stems 1 to 5 cm at 30 cm height were counted. The sum of the 12 subplots in each compartment was used to calculate the number of stems per hectare for each species. Visual estimates of percent cover were made for herbs and bryophytes in a 2 × 2 m quadrat positioned in the southwest corner of a 5 × 5 m quadrat that was centered in the tree plot. When species could not be identified in the field a sample was collected from inside or just outside of the plot for identification in the laboratory; this was the case for the majority of bryophytes. Mean cover per species was calculated for each compartment using counts from the six quadrats. Because of logistical issues, herbs were only quantified in a subset of 52 compartments in the pre-harvest survey (1998) but in all compartments in subsequent surveys.

Songbirds: We used surveys at one or two permanent point count stations (Bibby et al. 2000) in each compartment to assess the avifauna following methods described in Harrison et al. (2005). Trained observers conducted point count surveys between sunrise and 10:00h three times from late May to early July in 1998, and subsequent paired years in 1999, 2000, 2005, 2006, 2012 and 2013 (Odsen 2015). Observers recorded all birds seen or heard within a 50 m radius. Observations were summarized for analysis by taking the maximum count of the three survey periods for each species at each point or the average maximum count where two stations co-occurred in a single compartment. For post-harvest data, species maximum counts were averaged for each pair of years (1999/2000, 2005/2006 and 2012/2013).

References:

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Table A1. List of species belonging to each assemblage. Species included in regenerating trees are the same as tree species

Spiders	Spiders (contd.)	Spiders (contd.)
Agelenopsis utahana	*Diplocentria rectangulata*	*Linyphiidae* sp5
Agroeca ornata	*Diplocephalus subrostratus*	*Linyphiidae* sp6
Agyneta allosubtilis	*Dismodicus alticeps*	*Macrargus multesimus*
Agyneta olivacea	*Dismodicus decemoculatus*	*Maro amplus*
Allomengea dentisetis	*Dolomedes triton*	*Maso sundevalli*
Alopecosa aculeata	*Drassodes neglectus*	*Meioneta simplex*
Amaurobius borealis	*Emblyna annulipes*	*Meioneta* sp.
Araneus corticarius	*Enoplognatha intrepida*	*Mermessus trilobatus*
Araneus iviei	*Eridantes utibilis*	*Micaria aenea*
Araneus marmoreus	*Eris militaris*	*Micaria medica*
Araniella displicata	*Ero canionis*	*Micaria pulicaria*
Arctobius agelenoides	*Estrandia grandaeva*	*Micaria rossica*
Arctosa alpigena	*Euryopis argentea*	*Micaria tripunctata*
Arctosa raptor	*Evarcha proszynskii*	*Microlinyphia mandibulata*
Arctosa rubicunda	*Gnaphosa borea*	*Microlinyphia pusilla*
Argenna obesa	*Gnaphosa brumalis*	*Microneta viaria*
Baryphyma gowerense	*Gnaphosa microps*	*Misumena vatia*
Bassaniana utahensis	*Gnaphosa muscorum*	*Neoantistea agilis*
Bathyphantes brevipes	*Gnaphosa parvula*	*Neon nelli*
Bathyphantes brevis	*Gonatium crassipalpum*	*Neriene clathrata*
Bathyphantes pallidus	*Grammonota angusta*	*Neriene radiata*
Bathyphantes reprobus	*Grammonota gigas*	*Oedothorax alascensis*
Callobius nomeus	*Hahnia cinerea*	*Ohlertidion ohlerti*
Canalidion montanum	*Haplodrassus hiemalis*	*Oreonetides rectangulatus*
Centromerus furcatus	*Haplodrassus signifer*	*Oreonetides rotundus*
Ceraticelus atriceps	*Helophora insignis*	*Oreonetides vaginatus*
Ceraticelus bulbosus	*Hilaira canaliculata*	*Orodrassus canadensis*
Ceraticelus fissiceps	*Hilaira herniosa*	*Oryphantes aliquantulus*
Ceraticelus laetabilis	*Hybauchenidium gibbosum*	*Ozyptila gertschi*
Ceratinella brunnea	*Hypselistes florens*	*Ozyptila sincera canadensis*
Ceratinopsis labradorensis	*Hypsosinga alberta*	*Pardosa concinna*
Clubiona canadensis	*Hypsosinga rubens*	*Pardosa furcifera*
Clubiona chippewa	*Improphantes complicatus*	*Pardosa fuscula*
Clubiona furcata	*Incestophantes duplicatus*	*Pardosa groenlandica*
Clubiona kulczynskii	*Islandiana longisetosa*	*Pardosa hyperborea*
Clubiona moesta	*Kaestneria pullata*	*Pardosa mackenziana*
Cnephalocotes obscurus	*Larinioides sclopetarius*	*Pardosa moesta*
Collinsia clypiella	*Lepthyphantes alpinus*	*Pardosa tesquorum*
Coriarachne brunneipes	*Lepthyphantes intricatus*	*Pardosa uintana*
Crustulina sticta	*Lepthyphantes leprosus*	*Pardosa xerampelina*
Cryphoeca exlineae	*Lepthyphantes turbatrix*	*Pelecopsis bishopi*
Cybaeopsis euopla	*Linyphiidae* sp1	*Pelecopsis mengei*
Cyclosa conica	*Linyphiidae* sp2	*Pelecopsis moesta*
Dictyna brevitarsa	*Linyphiidae* sp3	*Pelecopsis sculpta*
Diplocentria bidentata	*Linyphiidae* sp4	*Pelegrina flavipes*

Spiders (contd.)	Spiders (contd.)	Carabids (contd)
Pelegrina insignis	*Theridion sexpunctatus*	*Agonum gratiosum*
Pelegrina montana	*Thymoites minnesota*	*Agonum placidum*
Pellenes lapponicus	*Tibellus maritimus*	*Agonum retractum*
Phidippus borealis	*Tibellus oblongus*	*Agonum sordens*
Philodromus cespitum	*Titanoeca nivalis*	*Agonum thoreyi*
Philodromus imbecillus	*Trochosa terricola*	*Amara aeneopolita*
Philodromus mysticus	*Tunagyna debilis*	*Amara apricaria*
Philodromus oneida	*Vermontia thoracica*	*Amara cupreolata*
Philodromus placidus	*Walckenaeria arctica*	*Amara erratica*
Philodromus rufus quartus	*Walckenaeria atrotibialis*	*Amara familiaris*
Pirata bryantae	*Walckenaeria auranticeps*	*Amara laevipennis*
Pirata canadensis	*Walckenaeria castanea*	*Amara latior*
Pirata insularis	*Walckenaeria communis*	*Amara lunicollis*
Pirata piraticus	*Walckenaeria cuspidata brevicula*	*Amara patruelis*
Pityohyphantes costatus	*Walckenaeria directa*	*Amara pseudobrunnea*
Pityohyphantes subarcticus	*Walckenaeria exigua*	*Amara sinuosa*
Pocadicnemis americana	*Walckenaeria fallax*	*Amara torrida*
Pocadicnemis pumila	*Walckenaeria karpinskii*	*Badister obtusus*
Porrhomma ocella	*Walckenaeria lepida*	*Bembidion grapii*
Porrhomma terrestre	*Walckenaeria minuta*	*Bembidion mutatum*
Praestigia kulczynskii	*Walckenaeria pullata*	*Bembidion nigripes*
Robertus fuscus	*Walckenaeria spiralis*	*Bembidion quadrimaculatum*
Rugathodes aurantius	*Walckenaeria subspiralis*	*Bembidion rupicola*
Rugathodes sexpunctatus	*Walckenaeria tricornis*	*Bembidion transparens*
Sciastes truncatus	*Walckenaerianus aimakensis*	*Blethisa multipunctata*
Scironis tarsalis	*Wubana drassoides*	*Calathus advena*
Scotinotylus alpinus	*Xysticus britcheri*	*Calathus ingratus*
Scotinotylus sacer	*Xysticus canadensis*	*Calosoma frigidum*
Scyletria inflata	*Xysticus elegans*	*Carabus chamissonis*
Semljicola obtusus	*Xysticus ellipticus*	*Carabus taedatus*
Sergiolus montanus	*Xysticus emertoni*	*Chlaenius purpuricollis*
Sibianor aemulus	*Xysticus ferox*	*Cymindis cribricollis*
Sisicottus crossoclavis	*Xysticus gertschi*	*Elaphrus clairvillei*
Sisicottus montanus	*Xysticus luctuosus*	*Elaphrus lapponicus*
Sisicus apertus	*Xysticus montanensis*	*Elaphrus pallipes*
Sisicus volutasilex	*Xysticus nigromaculatus*	*Harpalus amputatus*
Sisis rotundus	*Xysticus obscurus*	*Harpalus egregius*
Steatoda borealis	*Xysticus punctatus*	*Harpalus fulvilabris*
Styloctetor stativus	*Xysticus triguttatus*	*Harpalus lewisi*
Tapinocyba cameroni	*Zelotes fratris*	*Loricera pilicornis*
Tapinocyba simplex	*Zelotes puritanus*	*Miscodera arctica*
Tenuiphantes zebra	*Zornella armata*	*Nebria gyllenhali*
Tetragnatha versicolor	**Carabids**	*Notiophilus borealis*
Thanatus formicinus	*Agonum corvus*	*Notiophilus directus*
Thanatus striatus	*Agonum cupreum*	*Notiophilus semistriatus*

Carabids (contd.)	Songbirds (contd.)	Shrubs (contd.)
Patrobus foveocollis	*Melospiza georgiana*	*Amelanchier alnifolia*
Patrobus septentrionis	*Melospiza lincolnii*	*Betula glandulosa*
Platynus decentis	*Melospiza melodia*	*Betula pumila*
Platynus mannerheimii	*Mniotilta varia*	*Cornus stolonifera*
Poecilus lucublandus	*Molothrus ater*	*Lonicera dioica*
Pterostichus adstrictus	*Oporornis agilis*	*Ribes glandulosum*
Pterostichus brevicornis	*Oporornis philadelphia*	*Ribes hudsonianum*
Pterostichus lucublandus	*Parus atricapillus*	*Ribes lacustre*
Pterostichus pensylvanicus	*Parus hudsonicus*	*Ribes oxyacanthoides*
Pterostichus punctatissimus	*Pheucticus ludovicianus*	*Rosa acicularis*
Pterostichus riparius	*Piranga ludoviciana*	*Salix species*
Sericoda bembidioides	*Regulus calendula*	*Shepherdia canadensis*
Sericoda quadripunctata	*Regulus satrapa*	*Sorbus scopulina*
Stereocerus haematopus	*Sayornis phoebe*	*Viburnum edule*
Synuchus impunctatus	*Seiurus aurocapillus*	**Herbs**
Trechus apicalis	*Seiurus noveboracensis*	*Achillea millefolium*
Trechus chalybeus	*Setophaga palmarum*	*Achillea sibirica*
Trichocellus cognatus	*Setophaga ruticilla*	*Actaea rubra*
Songbirds	*Sitta canadensis*	*Adoxa moschatellina*
Agelaius phoeniceus	*Spizella pallida*	*Anemone canadensis*
Ammodramus leconteii	*Spizella passerina*	*Aralia nudicaulis*
Bombycilla cedrorum	*Tachycineta bicolor*	*Arenaria lateriflora*
Bonasa umbellus	*Troglodytes troglodytes*	*Arnica chamissonis*
Carduelis pinus	*Turdus migratorius*	*Arnica cordifolia*
Carpodacus purpureus	*Vermivora celata*	*Aster ciliolatus*
Catharus fuscescens	*Vermivora peregrina*	*Aster conspicuus*
Catharus guttatus	*Vireo gilvus*	*Aster puniceus*
Catharus ustulatus	*Vireo olivaceus*	*Astragalus alpinus*
Certhia americana	*Vireo philadelphicus*	*Astragalus americanus*
Contopus borealis	*Vireo solitarius*	*Botrychium lunaria*
Contopus sordidulus	*Wilsoni pusilla*	*Calypso bulbosa*
Dendroica castanea	*Wilsonia canadensis*	*Cardamine pensylvanica*
Dendroica coronata	*Zonotrichia albicollis*	*Chrysosplenium* spp.
Dendroica magnolia	**Trees**	*Circaea alpina*
Dendroica petechia	*Abies balsamea*	*Cirsium arvense*
Dendroica striata	*Betula papyrifera*	*Corallorhiza maculata*
Dendroica tigrina	*Larix laricina*	*Corallorhiza trifida*
Dendroica virens	*Picea glauca*	*Cornus canadensis*
Empidonax alnorum	*Picea mariana*	*Corydalis aurea*
Empidonax minimus	*Pinus contorta*	*Crepis tectorum*
Geothlypis trichas	*Populus balsamifera*	*Delphinium glaucum*
Icterus sp.	*Populus tremuloides*	*Disporum trachycarpum*
Ixoreus naevius	**Shrubs**	*Dracocephalum parviflorum*
Junco hyemalis	*Alnus crispa*	*Dryopteris carthusiana*
Loxia leucoptera	*Alnus tenuifolia*	*Epilobium angustifolium*

Herbs (contd.)	Herbs (contd.)	Bryophytes (contd.)
Epilobium ciliatum	*Petasites vitifolius*	*Campylium chrysophyllum*
Epilobium palustre	*Polemonium acutiflorum*	*Campylium hispidulum*
Epilobium sp.	*Potentilla norvegica*	*Campylium stellatum*
Equisetum arvense	*Pyrola asarifolia*	*Cephalozia* spp.
Equisetum pratense	*Pyrola chlorantha*	*Ceratodon purpureus*
Equisetum scirpoides	*Ranunculus abortivus*	*Chiloscyphus pallescens*
Equisetum sylvaticum	*Ranunculus gmelinii*	*Climacium dendroides*
Fragaria vesca	*Ranunculus lapponicus*	*Conocephalum conicum*
Fragaria virginiana	*Ranunculus macounii*	*Dicranum acutifolium*
Galium boreale	*Rhinanthus borealis*	*Dicranum flagellare*
Galium triflorum	*Rubus arcticus*	*Dicranum fragilifolium*
Gentianella amarella	*Rubus chamaemorus*	*Dicranum fuscescens*
Geocaulon lividum	*Rubus pubescens*	*Dicranum montanum*
Geranium bicknelli	*Senecio pauperculus*	*Dicranum polysetum*
Geum macrophyllum	*Sium suave*	*Dicranum scoparium*
Goodyera repens	*Smilacina stellata*	*Dicranum undulatum*
Gymnocarpium dryopteris	*Smilacina trifolia*	*Drepanocladus aduncus*
Habenaria hyperborea	*Solidago canadensis*	*Drepanocladus uncinatus*
Habenaria obtusata	*Stellaria calycantha*	*Dreplanocladus polygamus*
Habenaria orbiculata	*Stellaria longifolia*	*Eurhynchium pulchellum*
Habenaria viridis	*Taraxacum officinale*	*Funaria hygrometrica*
Halenia deflexa	*Taraxacum* sp.	*Geocalyx graveolens*
Heracleum lanatum	*Thalictrum sparsiflorum*	*Helodium blandowii*
Hieracium umbellatum	*Thalictrum venulosum*	*Herzogiella turfacea*
Impatiens noli-tangere	*Trientalis borealis*	*Hylocomium splendens*
Lathyrus ochroleucus	*Trifolium hybridum*	*Hypnum pratense*
Lathyrus venosus	*Urtica dioica*	*Isopterygium pulchellum*
Linnaea borealis	*Vaccinium vitis-idaea*	*Jamesoniella autumnalis*
Listera cordata	*Vicia americana*	*Lepidozia reptans*
Lycopodium annotinum	*Viola adunca*	*Leptobryum pyriforme*
Lycopodium complanatum	*Viola canadensis*	*Leptodictyum riparium*
Maianthemum canadense	*Viola palustris*	*Liverwort* sp.
Mentha arvensis	*Viola renifolia*	*Lophocolea heterophylla*
Mertensia paniculata	**Bryophytes**	*Lophocolea minor*
Mitella nuda	*Amblystegium serpens*	*Lophocolea* sp.
Moehringia lateriflora	*Anastrophyllum hellarianum*	*Lophozia* spp.
Moneses uniflora	*Aneura pinguis*	*Marchantia polymorpha*
Mos ada	*Aulacomnium palustre*	*Mnium spinulosum*
Orthilia secunda	*Blepharostoma trichophyllum*	*Mylia anomala*
Osmorhiza depauperata	*Brachythecium* spp.	*Oncophorus wahlenbergii*
Oxycoccus microcarpus	*Bryohaplocladium microphyllum*	*Orthotrichum obtusifolium*
Pedicularis labradorica	*Bryum* spp.	*Orthotrichum* sp.
Petasites frigidus	*Calliergon cordifolium*	*Orthotrichum speciosum*
Petasites palmatus	*Calliergon richardsonii*	*Plagiochila porelloides*
Petasites sagittatus	*Calypogeja* sp.	*Plagiomnium ciliare*

Bryophytes (contd.)
Plagiomnium cuspidatum
Plagiomnium drummondii
Plagiomnium ellipticum
Plagiomnium medium
Plagiothecium denticulatum
Plagiothecium laetum
Platydictya jungermannioides
Pleurozium schreberi
Pohlia cruda
Pohlia nutans
Polytrichum commune
Polytrichum juniperinum
Polytrichum sp.
Polytrichum strictum
Ptilidium pulcherrimum
Ptilium crista-castrensis
Pylaisiella polyantha
Rhizomnium gracile
Rhizomnium pseudopunctatum
Rhytidiadelphus triquetrus
Riccardia spp.
Sanionia uncinata
Scapania curta
Scapania glaucocephala
Sphagnum spp.
Tetraphis pellucida
Thuidium recognitum
Tomenthypnum nitens
Tritomaria exsectiformis

Figure A1. Schematic description of the statistical analysis and number of experimental units included in each of them

Question 1: How are forest composition and structure related to historical fire events?

Variables	Type of variable	Number of pre-harvest compartments
Fire history	Constraining	100
Tree basal area	Response	100

↓

One RDA ordination

Question 2: Is structure of present biotic assemblages related to forest composition and structure established by historical fires?

Variables	Type of variable	Number of pre-harvest compartments
Tree basal area	Constraining	100
Spiders	Response	12
Carabids	Response	12
Songbirds	Response	72
Tree regeneration	Response	100
Shrubs	Response	100
Forbs	Response	52
Bryophytes	Response	52

↓

One RDA ordination for each response variable

Question 3: Does fire history affect recovery of the forest biota toward pre-harvest conditions two, five and ten years after variable retention harvest?

Variables	Type of variable	Number of pre-harvest compartments	Number of post-harvest compartments at 2, 5 and 10 years post-harvest
Tree basal area	Constraining	72	72
Spiders	Response	na	72
Carabids	Response	na	72
Songbirds	Response	na	72
Tree regeneration	Response	na	72
Shrubs	Response	na	72
Forbs	Response	na	72
Bryophytes	Response	na	72

↓

One PCA ordination for tree basal area in each sampling year

↓

Extract PCA loadings for each sampling year

↓

21 variance partitioning analyses (7 assemblages in 3 post-harvest years) using pre- and post-harvest PCA loadings as constraining variables

Figure A2. RDA ordination of pre-harvest basal area for each tree species in the 100 forest compartments (empty circles) as constrained by fire history variables (%1895: proportion of stems in the stand recruited after the fire of 1895, %1877: proportion of stems in the stand recruited after the fire of 1877, %pre1837: proportion of stems in the stand recruited before the fire of 1837, Time since fire: number of years between the earliest important fire in the stand and time of harvesting). Only vectors for significant constraining variables are shown and length of each arrow corresponds to the strength of the correlation between the constraining variable and the site scores. Basal areas for eight tree species were included in the model but five were omitted from the figure as they were overlapping in the center. Ellipses representing 95% confidence intervals around group centroids for cover types are also drawn to enhance interpretation. Overall model significance: p=0.001; adj. R^2= 0.46; Aw: *Populus tremuloides*, Pb: *Populus balsamifera*, Sw: *Picea glauca*

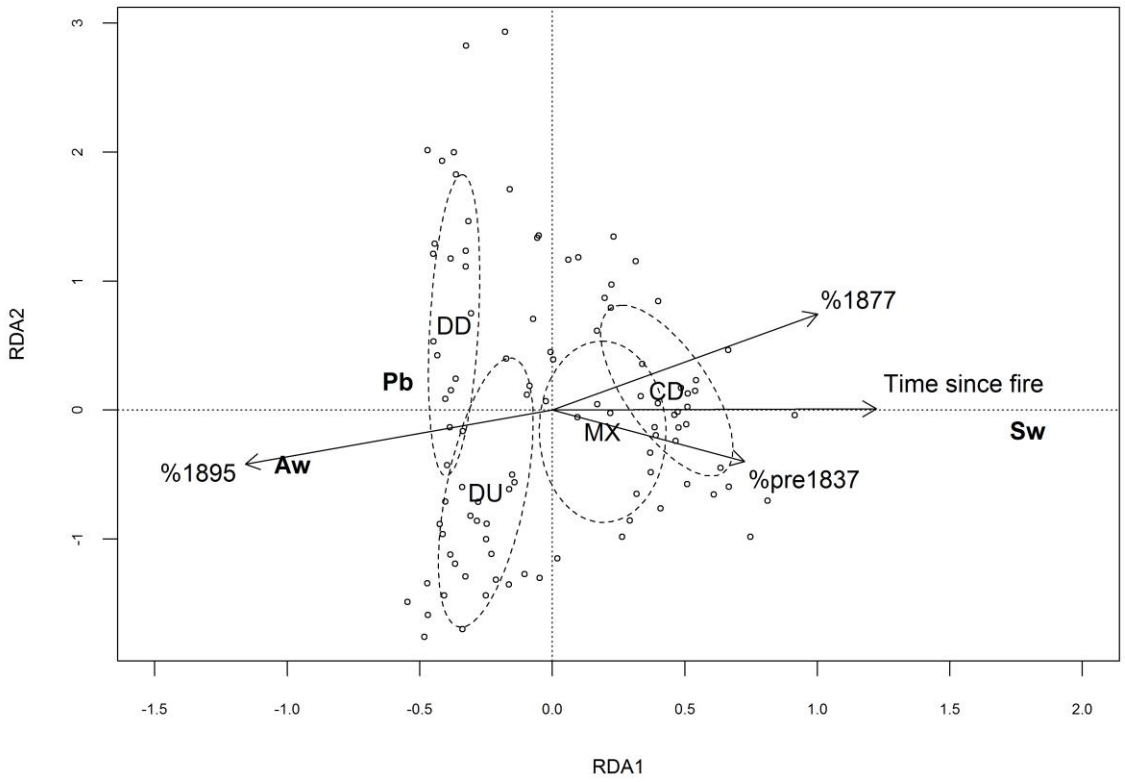

Figure A3. RDA ordinations of the seven pre-harvest assemblages as constrained by pre-harvest tree basal area. All models were significant at $p \leq 0.001$. Adjusted R squared for spiders: 0.16, carabid beetles: 0.52, songbirds: 0.10, tree regeneration: 0.17, shrubs: 0.17, herbs: 0.17, and bryophytes: 0.27. Vectors for significant constraining variables are in bold and non-significant constraining variables were included as dashed lines to enhance interpretation. Ellipses representing 95% confidence intervals around group centroids for cover types are also drawn for the same reason.