

Blois, J. L., Gotelli, N. J., Behrensmeier, A. K., Faith, J. T., Lyons, S. K., Williams, J. W., Amatangelo, K. L., Bercovici, A., Du, A., Eronen, J. T., Graves, G. R., Jud, N., Labandeira, C., Looy, C., McGill, B., Patterson, D., Potts, R., Riddle, B., Terry, R., Tóth, A., Villaseñor, A. and Wing, S. 2014. A framework for evaluating the influence of climate, dispersal limitation, and biotic interactions using fossil pollen associations across the late Quaternary. – *Ecography* doi: 10.1111/ecog.00779

Supplementary material

Appendix 1

Table A1. Proportion of variance explained by the three principal components at each time slice, followed by the loadings of each variable on the first and second principal components.

| Age (kyr BP) | Proportion of Variance | | | Comp.1 Loadings | | | Comp.2 Loadings | | |
|-----------------|------------------------|--------|--------|-----------------|---------|---------|-----------------|---------|---------|
| | | | | Winter | | Summer | Winter | | Summer |
| | PCA1 | PCA2 | PCA3 | Precip | Temp | Temp | Precip | Temp | Temp |
| 0 | 0.8407 | 0.1421 | 0.0172 | -0.5396 | -0.6179 | -0.5718 | 0.7819 | -0.1160 | -0.6125 |
| 1 | 0.7954 | 0.1866 | 0.0179 | -0.5105 | -0.6332 | -0.5818 | 0.8176 | -0.1480 | -0.5564 |
| 2 | 0.7881 | 0.1947 | 0.0172 | -0.5081 | -0.6373 | -0.5794 | 0.8123 | -0.1309 | -0.5684 |
| 3 | 0.7754 | 0.2022 | 0.0225 | -0.5004 | -0.6386 | -0.5847 | 0.8251 | -0.1470 | -0.5456 |
| 4 | 0.7668 | 0.2153 | 0.0179 | -0.4884 | -0.6448 | -0.5880 | 0.8326 | -0.1426 | -0.5351 |
| 5 | 0.7611 | 0.2165 | 0.0224 | -0.4994 | -0.6464 | -0.5768 | 0.8080 | -0.1072 | -0.5794 |
| 6 | 0.7407 | 0.2355 | 0.0238 | -0.4896 | -0.6553 | -0.5752 | 0.8065 | -0.0895 | -0.5845 |
| 7 | 0.7039 | 0.2704 | 0.0257 | -0.4648 | -0.6724 | -0.5760 | 0.8115 | -0.0632 | -0.5810 |
| 8 | 0.6684 | 0.3090 | 0.0226 | -0.4095 | -0.6933 | -0.5930 | -0.8407 | 0.0343 | 0.5405 |
| 9 | 0.6720 | 0.3040 | 0.0240 | -0.4272 | -0.6905 | -0.5837 | -0.8261 | 0.0357 | 0.5623 |
| 10 | 0.6574 | 0.3134 | 0.0293 | -0.4307 | -0.6956 | -0.5750 | 0.8125 | -0.0215 | -0.5825 |
| 11 | 0.6826 | 0.2919 | 0.0254 | -0.4507 | -0.6840 | -0.5736 | 0.8089 | -0.0413 | -0.5864 |
| 12 | 0.7485 | 0.2338 | 0.0177 | -0.4720 | -0.6533 | -0.5920 | 0.8409 | -0.1319 | -0.5249 |
| 13 | 0.7518 | 0.2259 | 0.0223 | -0.4870 | -0.6499 | -0.5835 | 0.8235 | -0.1189 | -0.5547 |
| 14 | 0.7221 | 0.2231 | 0.0548 | -0.4707 | -0.6280 | -0.6197 | 0.8813 | -0.3017 | -0.3636 |
| 15 | 0.7795 | 0.1774 | 0.0431 | -0.5090 | -0.6104 | -0.6069 | 0.8605 | -0.3433 | -0.3764 |
| 16 | 0.7976 | 0.1635 | 0.0389 | -0.5176 | -0.6036 | -0.6064 | 0.8554 | -0.3802 | -0.3516 |
| 17 | 0.7565 | 0.2040 | 0.0395 | 0.4889 | 0.6043 | 0.6291 | 0.8628 | -0.4411 | -0.2469 |
| 18 | 0.7658 | 0.1809 | 0.0533 | -0.5218 | -0.5836 | -0.6222 | 0.8213 | -0.5410 | -0.1813 |
| 19 | 0.7092 | 0.2357 | 0.0551 | 0.4888 | 0.5827 | 0.6493 | 0.8216 | -0.5576 | -0.1182 |
| 20 | 0.7330 | 0.2044 | 0.0626 | -0.4973 | -0.6031 | -0.6237 | 0.8603 | -0.4355 | -0.2649 |
| 21 | 0.8078 | 0.1391 | 0.0531 | 0.5432 | 0.5826 | 0.6046 | 0.8180 | -0.5294 | -0.2249 |

Table A3. Taxon pairs associated with Figure 4.

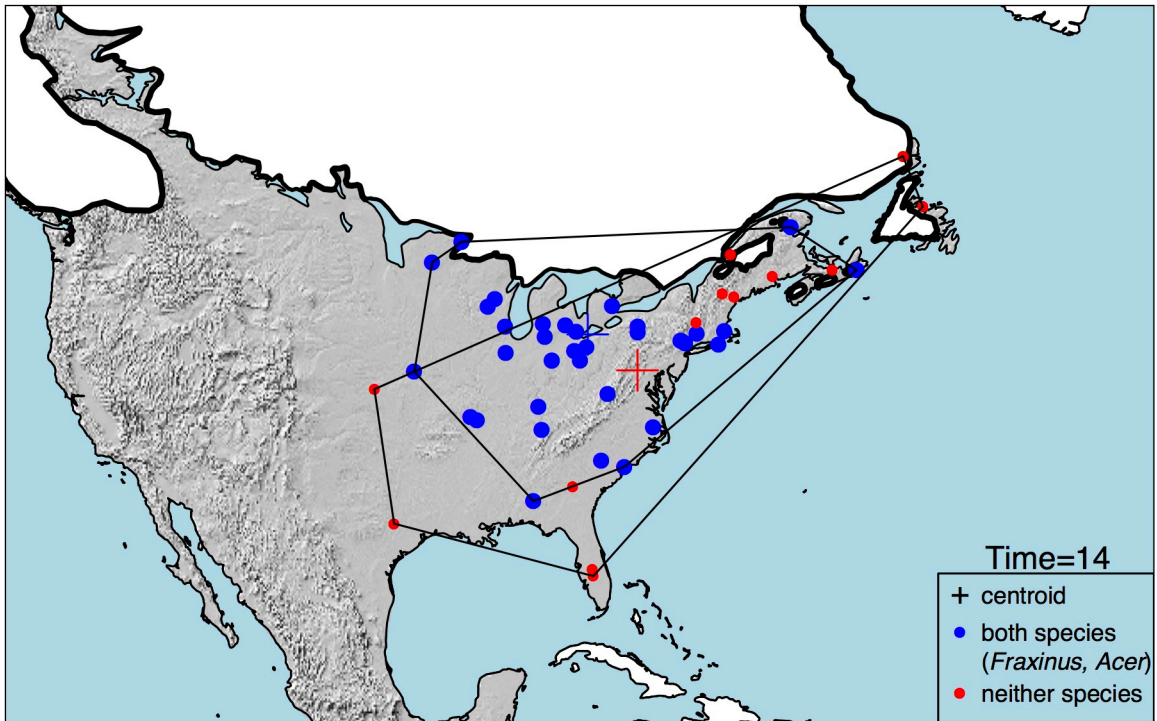
| Pair Number | Segregated Pairs | Pair Number | Aggregated Pairs |
|-------------|-------------------------------------|-------------|---------------------------------|
| 1 | <i>Abies-Bidens</i> | 1 | <i>Picea-Abies</i> |
| 2 | <i>Abies-Castanea</i> | 2 | <i>Abies-Taxus</i> |
| 3 | <i>Abies-Liquidambar</i> | 3 | <i>Acer-Castanea</i> |
| 4 | <i>Abies-Magnolia</i> | 4 | <i>Fraxinus-Acer</i> |
| 5 | <i>Abies-Taxodium</i> | 5 | <i>Acer-Platanus</i> |
| 6 | <i>Abies-Vitis</i> | 6 | <i>Acer-Tilia</i> |
| 7 | <i>Acer-Epilobium</i> | 7 | <i>Ulmus-Acer</i> |
| 8 | <i>Acer-Gordonia</i> | 8 | <i>Ambrosia.type-Celtis</i> |
| 9 | <i>Acer-Potentilla</i> | 9 | <i>Ambrosia.type-Iva</i> |
| 10 | <i>Acer-Sanguisorba</i> | 10 | <i>Ambrosia.type-Polygonum</i> |
| 11 | <i>Alnus-Stachys</i> | 11 | <i>Ambrosia.type-Sarcobatus</i> |
| 12 | <i>Alnus-Waltheria</i> | 12 | <i>Ambrosia.type-Tilia</i> |
| 13 | <i>Ambrosia.type-Arctostaphylos</i> | 13 | <i>Amorpha-Dalea</i> |
| 14 | <i>Juglans-Amorpha</i> | 14 | <i>Amorpha-Ephedra</i> |
| 15 | <i>Quercus-Arctostaphylos</i> | 15 | <i>Iva-Amorpha</i> |
| 16 | <i>Ulmus-Arctostaphylos</i> | 16 | <i>Salix-Amorpha</i> |
| 17 | <i>Artemisia-Bursera</i> | 17 | <i>Artemisia-Rumex.Oxyria</i> |
| 18 | <i>Artemisia-Gordonia</i> | 18 | <i>Artemisia-Sarcobatus</i> |
| 19 | <i>Artemisia-Itea</i> | 19 | <i>Artemisia-Shepherdia</i> |
| 20 | <i>Artemisia-Liriodendron</i> | 20 | <i>Cephalanthus-Bidens</i> |
| 21 | <i>Artemisia-Magnolia</i> | 21 | <i>Iva-Bidens</i> |
| 22 | <i>Artemisia-Tilia</i> | 22 | <i>Liquidambar-Bidens</i> |
| 23 | <i>Betula-Gordonia</i> | 23 | <i>Bidens-Magnolia</i> |
| 24 | <i>Betula-Nyssa</i> | 24 | <i>Polygonum-Bidens</i> |
| 25 | <i>Betula-Opuntia</i> | 25 | <i>Bidens-Sambucus</i> |
| 26 | <i>Betula-Polygonella</i> | 26 | <i>Tilia-Bidens</i> |
| 27 | <i>Betula-Sisyrinchium</i> | 27 | <i>Viburnum-Bidens</i> |
| 28 | <i>Betula-Stachys</i> | 28 | <i>Bidens-Xanthium</i> |
| 29 | <i>Betula-Taxodium</i> | 29 | <i>Carya-Castanea</i> |
| 30 | <i>Betula-Waltheria</i> | 30 | <i>Carya-Celtis</i> |
| 31 | <i>Betula-Xyris</i> | 31 | <i>Carya-Cephalanthus</i> |
| 32 | <i>Larix-Bidens</i> | 32 | <i>Carya-Fagus</i> |
| 33 | <i>Picea-Bidens</i> | 33 | <i>Carya-Ilex</i> |
| 34 | <i>Tsuga-Bidens</i> | 34 | <i>Carya-Juglans</i> |
| 35 | <i>Corylus-Bursera</i> | 35 | <i>Carya-Liquidambar</i> |
| 36 | <i>Fagus-Bursera</i> | 36 | <i>Carya-Nyssa</i> |
| 37 | <i>Fraxinus-Bursera</i> | 37 | <i>Carya-Platanus</i> |
| 38 | <i>Ostrya.Carpinus-Bursera</i> | 38 | <i>Carya-Viburnum</i> |
| 39 | <i>Picea-Bursera</i> | 39 | <i>Fagus-Castanea</i> |
| 40 | <i>Populus-Bursera</i> | 40 | <i>Fraxinus-Castanea</i> |

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|----|---------------------------------|----|-------------------------------------|
| 41 | <i>Tsuga-Bursera</i> | 41 | <i>Ostrya.Carpinus-Castanea</i> |
| 42 | <i>Ulmus-Bursera</i> | 42 | <i>Tsuga-Castanea</i> |
| 43 | <i>Carya-Epilobium</i> | 43 | <i>Celtis-Cornus</i> |
| 44 | <i>Carya-Spiraea</i> | 44 | <i>Cephalanthus-Itea</i> |
| 45 | <i>Carya-Symphoricarpos</i> | 45 | <i>Nyssa-Cephalanthus</i> |
| 46 | <i>Thalictrum-Celtis</i> | 46 | <i>Cephalanthus-Sambucus</i> |
| 47 | <i>Larix-Clethra</i> | 47 | <i>Chamaedaphne.calyc-Vaccinium</i> |
| 48 | <i>Picea-Clethra</i> | 48 | <i>Liquidambar-Clethra</i> |
| 49 | <i>Corylus-Ilex</i> | 49 | <i>Sambucus-Clethra</i> |
| 50 | <i>Corylus-Nyssa</i> | 50 | <i>Taxodium-Clethra</i> |
| 51 | <i>Corylus-Planera.aquatica</i> | 51 | <i>Fagus-Cornus</i> |
| 52 | <i>Corylus-Vitis</i> | 52 | <i>Taxodium-Cyrilla.racemiflor</i> |
| 53 | <i>Picea-Cyrilla.racemiflor</i> | 53 | <i>Iva-Dalea</i> |
| 54 | <i>Tsuga-Cyrilla.racemiflor</i> | 54 | <i>Sarcobatus-Dalea</i> |
| 55 | <i>Ulmus-Cyrilla.racemiflor</i> | 55 | <i>Dalea-Xanthium</i> |
| 56 | <i>Fagus-Dalea</i> | 56 | <i>Iva-Ephedra</i> |
| 57 | <i>Tsuga-Dalea</i> | 57 | <i>Epilobium-Symphoricarpos</i> |
| 58 | <i>Fraxinus-Epilobium</i> | 58 | <i>Eriogonum-Stachys</i> |
| 59 | <i>Tsuga-Epilobium</i> | 59 | <i>Fagus-Liquidambar</i> |
| 60 | <i>Ulmus-Epilobium</i> | 60 | <i>Fagus-Nyssa</i> |
| 61 | <i>Fagus-Gordonia</i> | 61 | <i>Fagus-Tsuga</i> |
| 62 | <i>Fagus-Melilotus</i> | 62 | <i>Fagus-Viburnum</i> |
| 63 | <i>Fagus-Salsola</i> | 63 | <i>Ostrya.Carpinus-Fraxinus</i> |
| 64 | <i>Fagus-Symphoricarpos</i> | 64 | <i>Fraxinus-Platanus</i> |
| 65 | <i>Fagus-Taxodium</i> | 65 | <i>Fraxinus-Tilia</i> |
| 66 | <i>Fraxinus-Juniperus.Thuja</i> | 66 | <i>Xanthium-Galium</i> |
| 67 | <i>Fraxinus-Symphoricarpos</i> | 67 | <i>Liquidambar-Gordonia</i> |
| 68 | <i>Picea-Gordonia</i> | 68 | <i>Liriodendron-Gordonia</i> |
| 69 | <i>Tsuga-Gordonia</i> | 69 | <i>Magnolia-Gordonia</i> |
| 70 | <i>Picea-Hypericum</i> | 70 | <i>Gordonia-Parthenocissus</i> |
| 71 | <i>Picea-Itea</i> | 71 | <i>Taxodium-Gordonia</i> |
| 72 | <i>Tsuga-Itea</i> | 72 | <i>Nyssa-Hypericum</i> |
| 73 | <i>Larix-Liquidambar</i> | 73 | <i>Sambucus-Hypericum</i> |
| 74 | <i>Larix-Magnolia</i> | 74 | <i>Ilex-Liquidambar</i> |
| 75 | <i>Larix-Taxodium</i> | 75 | <i>Nyssa-Ilex</i> |
| 76 | <i>Picea-Liquidambar</i> | 76 | <i>Tsuga-Ilex</i> |
| 77 | <i>Salix-Liquidambar</i> | 77 | <i>Ilex-Vitis</i> |
| 78 | <i>Picea-Liriodendron</i> | 78 | <i>Polygonum-Itea</i> |
| 79 | <i>Pinus-Liriodendron</i> | 79 | <i>Taxodium-Itea</i> |
| 80 | <i>Picea-Magnolia</i> | 80 | <i>Vitis-Itea</i> |
| 81 | <i>Thalictrum-Nyssa</i> | 81 | <i>Iva-Planera.aquatica</i> |
| 82 | <i>Picea-Parthenocissus</i> | 82 | <i>Iva-Sarcobatus</i> |
| 83 | <i>Picea-Planera.aquatica</i> | 83 | <i>Iva-Xanthium</i> |

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|----|-------------------------------|-----|-------------------------------------|
| 84 | <i>Picea-Spiraea</i> | 84 | <i>Ostrya.Carpinus-Juglans</i> |
| 85 | <i>Picea-Stachys</i> | 85 | <i>Juniperus.Thuja-Nemopanthus</i> |
| 86 | <i>Picea-Taxodium</i> | 86 | <i>Picea-Juniperus.Thuja</i> |
| 87 | <i>Tsuga-Planera.aquatica</i> | 87 | <i>Salix-Juniperus.Thuja</i> |
| 88 | <i>Populus-Taxodium</i> | 88 | <i>Picea-Larix</i> |
| 89 | <i>Salix-Taxodium</i> | 89 | <i>Liquidambar-Liriodendron</i> |
| 90 | <i>Tsuga-Taxodium</i> | 90 | <i>Liquidambar-Magnolia</i> |
| | | 91 | <i>Liquidambar-Nyssa</i> |
| | | 92 | <i>Liquidambar-Polygonella</i> |
| | | 93 | <i>Liquidambar-Taxodium</i> |
| | | 94 | <i>Liquidambar-Viburnum</i> |
| | | 95 | <i>Liquidambar-Vitis</i> |
| | | 96 | <i>Magnolia-Liriodendron</i> |
| | | 97 | <i>Nyssa-Liriodendron</i> |
| | | 98 | <i>Vitis-Liriodendron</i> |
| | | 99 | <i>Nyssa-Magnolia</i> |
| | | 100 | <i>Magnolia-Taxodium</i> |
| | | 101 | <i>Vitis-Magnolia</i> |
| | | 102 | <i>Taxus-Nemopanthus</i> |
| | | 103 | <i>Nyssa-Taxodium</i> |
| | | 104 | <i>Nyssa-Vitis</i> |
| | | 105 | <i>Osmanthus-Xyris</i> |
| | | 106 | <i>Ostrya.Carpinus-Platanus</i> |
| | | 107 | <i>Ostrya.Carpinus-Tilia</i> |
| | | 108 | <i>Ostrya.Carpinus-Vitis</i> |
| | | 109 | <i>Picea-Sarcobatus</i> |
| | | 110 | <i>Picea-Taxus</i> |
| | | 111 | <i>Planera.aquatica-Polygonella</i> |
| | | 112 | <i>Sambucus-Planera.aquatica</i> |
| | | 113 | <i>Taxodium-Planera.aquatica</i> |
| | | 114 | <i>Vitis-Planera.aquatica</i> |
| | | 115 | <i>Ulmus-Platanus</i> |
| | | 116 | <i>Polygonella-Taxodium</i> |
| | | 117 | <i>Vitis-Polygonella</i> |
| | | 118 | <i>Polygonella-Xyris</i> |
| | | 119 | <i>Polygonum-Sanguisorba</i> |
| | | 120 | <i>Populus-Shepherdia</i> |
| | | 121 | <i>Populus-Taxus</i> |
| | | 122 | <i>Potentilla-Prunus</i> |
| | | 123 | <i>Sambucus-Prunus</i> |
| | | 124 | <i>Spiraea-Prunus</i> |
| | | 125 | <i>Ranunculus-Stellaria</i> |
| | | 126 | <i>Salix-Sarcobatus</i> |

| | |
|-----|----------------------------|
| 127 | <i>Salix-Taxus</i> |
| 128 | <i>Sambucus-Spiraea</i> |
| 129 | <i>Sarcobatus-Xanthium</i> |
| 130 | <i>Sisyrinchium-Xyris</i> |
| 131 | <i>Vitis-Taxodium</i> |
| 132 | <i>Tsuga-Taxus</i> |

A)



B)

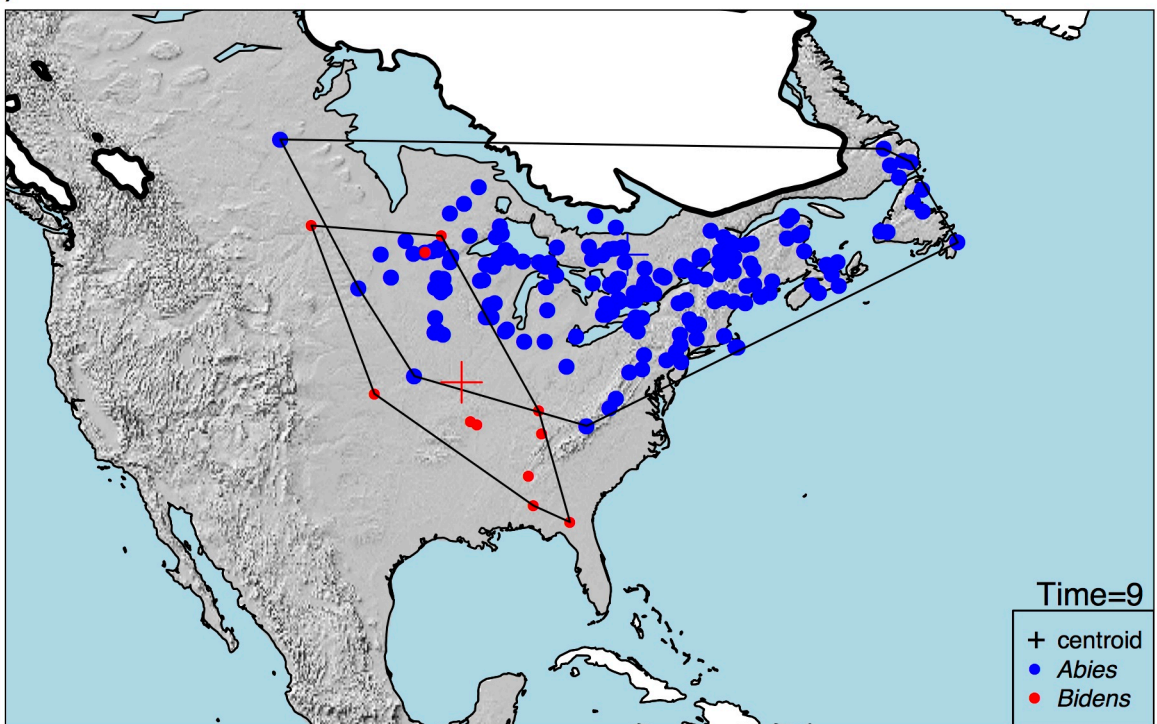


Figure A1. Representative maps showing the spatial pattern of site occupancy for some of the significantly aggregated or segregated taxon pairs. A) Syntopic sites with both members of the

aggregated pair *Fraxinus* and *Acer* at 14 kyr BP (blue) versus empty sites with neither pair (red), showing the centroids (+) for each polygon. This pair represents a potential biotic interaction, so there were no significant differences in either climate or geographic centroid among syntopic vs. empty sites. B) Sites with either *Abies* (blue) or *Bidens* (red), showing the centroids (+) for each polygon. This pair is significantly segregated, and is associated with significant differences in both climate (not shown) and geographic centroids.

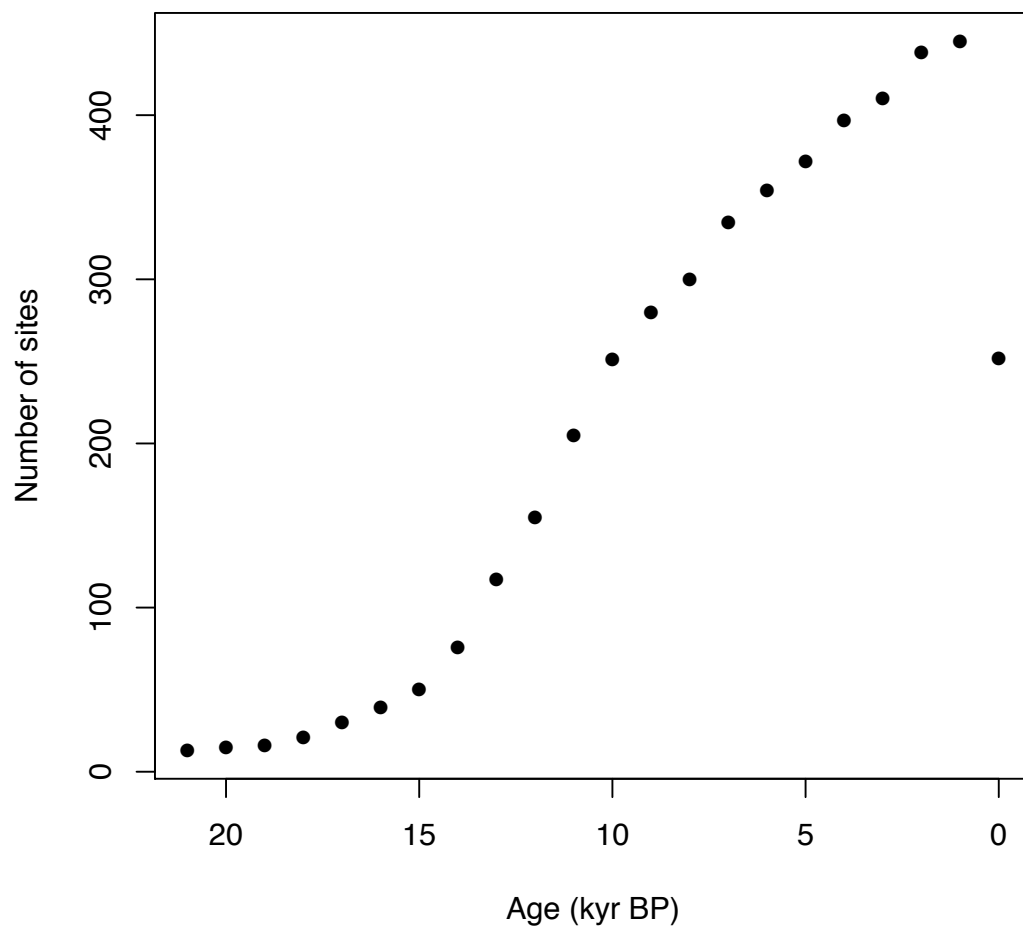


Figure A2. Number of sites through time.