**Bee Protocol**

Bees were observed by a single observer walking along a permanent transect line.

Observer walked a line parallel to the transect at a length of 1.5m to the left of the transect at a pace of 2 minutes/10m for a total of 20 minutes, covering 100m. Observer visually surveyed a 3m wide band of the 180° in front of themselves, recording every visual detection of a bee nectaring on a blooming floral resource.

Transect length differed between sites. Transect length was either 70m or 100m.

If transect was shorter than 100m, observer stopped the time once reaching the end of the transect, walked around the plot, and continued the survey at the starting point of the transect, walking until 20 minutes (100m of length) had been surveyed.

Individual data sheets:

If no bees were observed, header is present but no data is listed.

Section length: 2016 see file ‘2016\_survey\_dates\_transect\_length’ data sheet to determine if sections were 10m or 20m in length. 2017, 2018 section length always 10m.

‘Pollinator Species’ (2016) ‘Bee species’ (2017 and years following). Name changed but data did not.

‘honey bee’

‘bumble bee’

‘solitary bee’ all bees which were not ‘honey bee’ or ‘bumble bee’ were classified as ‘solitary bee’

‘Nectar Plant Species’

The floral resource on which the bee was nectaring at the time of observation was recorded by its common name. Common names and corresponding scientific names are recorded in the file ‘nectar\_species\_scientific\_name\_counting\_unit’ located in the folder 'data-raw/nectar' in the Git repository ISUmonarch.

**Monarch Protocol**

**Adult Monarchs**

Monarchs were observed by a single observer walking along a permanent transect line.

Observer walked a line parallel to the transect immediately to the left of the transect at a pace of 2 minutes/10m for a total of 20 minutes, covering 100m. Observer visually surveyed the 180° in front of themselves, recording every visual detection of an adult monarch butterfly. Observer made their best effort not to recount the same individual.

**2016 Notes**

Protocol inconsistencies: Observers were supposed to walk the transect at a speed of 2 minutes/10m section (which they did correctly). For round 1/2 of 2016 only, if the transect was shorter than 100m they were supposed to continue to observe at the end of the transect while stationary until reaching a total of 20 minutes of survey time. This stationary observation only occurred if the site was shorter than 100m and the observer completed a 20 minute survey as they were supposed to. This stationary observation did not occur if the observer errored and stopped collecting data at the end of the transect, having not reached 20 minutes of total observation time. These errors resulted in observation times shorter than 20 minutes, as is detailed in the file ‘2016\_survey\_dates\_transect\_length’.

Weather data: Weather data which was recorded on the physical ‘monarch’ data sheets was not used in the ‘monarch’ data set for round 1 2016. Weather data was derived from ‘landscape’ datasheets for round 1 2016 and was not recorded in Git in the ‘landscape’ data set. ‘landscape’ weather data used correct formatting. ‘monarch’ physical data sheet line items were incorrect in round 1 2016. Weather data line items were removed from ‘landscape’ data set after round 1 2016. Physical data sheet line items were resolved for ‘monarch’ data set and weather data was recorded in ‘monarch’ data set for round 2 and 3 2016. All 2017 and following years weather data was recorded in ‘environment’ data set and in no other data set.

‘wind’ terminology changed. Definition of each of the 4 categories of wind was subjective to the observer; not based on any defined scale.

Round1: calm, light, moderate, very windy

Round2/3: calm, breeze, moderate breeze, too windy to monitor

‘sky’

‘Clear’: no clouds.

‘Mostly clear’: <50% cloud cover

‘Mostly cloudy’: >50% cloud cover

‘Cloudy’: 100% cloud cover

\*’Rain’: rain (was not explicitly listed on 2016 data sheet but was always written down. 2017 ‘sky’ data in ‘environment’ data set contains same 5 categories, all explicitly listed)

‘temp’

°F. Data was collected from nearest weather station using various apps accessible via mobile device at time of data collection

‘start\_time’, ‘end\_time’

Only 2016 data included an end time

Written in ##:##AM or ##:##PM format. If hour was a single number, a zero was not written in front.

‘start\_time’, ‘end\_time’ (length of survey mistakes)

start\_time and end\_time should have always been 20 minutes apart. A 20 minute survey in total. Observer mistakes were made and survey time varied at select sites and rounds. See '2016\_survey\_dates\_transect\_lengths' document for length in minutes of each survey. Length of survey is sometimes NA due to missing data.

Plot outline

round 1/2, only the transect location was decided. No plot borders had been established.

Sections were only used for round 1/2 data 2016.

An observation within a section indicates the number of an adult monarchs observed within the plot while standing in the section noted.

Section length: 2016- see datasheet or '2016\_survey\_dates\_transect\_lengths' document to determine if sections were 10m or 20m.

Bins were only used for round 3 data 2016

An observation indicates that an adult monarch was observed at that distance from the observer who was observing the 180° in front of themselves.

Transect length not constant

transect length changed as noted in '2016\_survey\_dates\_transect\_lengths' at sites: cre1, nkn1, nkn2, sie1, pre1a

Resampling, Round 3: ber3, dun2, har1, van2, fis1, vos1, jon1

'stems', 'eggs', 'instar' data was collected on 8/11/2016 but adult monarch data was not taken because of rain. Adult monarch data was sampled on 8/17/2016 to make up for missed data. No 'stems', 'eggs', 'instar' data was collected on 8/17/2016.

Missing data: Data is NA as site did not yet exist.

Round 1: ber3, dun3, bcr1, bcr2, tie1, app1

Round 2: app1

Missing data: Data is NA as transect location was moved.

Round 1: uth3, arm1, nor1

Round 2: nor1

'extra\_monarch'

a monarch seen outside the monitoring time, anywhere at the site. This data was not listed as a line item on the data sheets. This data only exists if the observer voluntarily wrote down this observation.

'watch\_monarch'

a monarch seen during the monitoring time while the observer was standing still observing at the end of the transect. This data only exists for round 1/2 data in 2016 and was not listed as a specific line item on the data sheets. Observers were supposed to walk the transect at a speed of 2 minutes/10m section (which they did correctly). If the transect was shorter than 100m they were supposed to continue to observe at the end of the transect while stationary until reaching a total of 20 minutes of survey time. 'watch\_monarch' only occurred if the site was shorter than 100m and the observer completed a 20 minute survey as they were supposed to. The observer would do 'watch\_monarch' for as long as the time of the 20 minutes was remaining after reaching the end of the transect. 'watch\_monarch' did not occur if the observer errored and stopped collecting data at the end of the transect, having not reached 20 minutes of total observation time.

'stems'

the number of milkweed ramets observed with an upper limit of 20 ramets. Stems were counted if they were anywhere in the vicinity of the transect for all rounds as plot borders were not yet marked until round 3. Milkweed species was not specified but was almost always common milkweed. If 'stems' = 0, no rows for 'eggs' or 'instars' are listed

**2017 Notes**

Transect length

transect length remained the same as round 3 2016 except at sut2 and pre1a

Missing data: funding cut.

Round 1 data NA (not sampled) for sites under grant 'pork'. pre1a, pre1b, pre2a, pre2b, pre3a, pre3b, pre4a, pre4b, bcr1, bcr2, tie1, app1

No survey, rain. 8-15-17 fis1. No resampling done.

'NA' was entered for 'start\_time', '#\_inside\_plot', '#\_outside\_plot', 'extra\_monarchs'

Resample, missing data.

Cra1 was resampled for 'bee' and 'environment' data 8-30-17 from original date of 8-15-17

**2017 and Following Years Notes**

Transect length

transect length remained the same across all surveys

Survey length

surveys were always 20 minutes long

'#\_inside\_plot' and '#\_outside\_plot'

count data of adult monarchs observed during a survey where first sighting was either inside the plot or outside the defined plot perimeter

'common\_ramets' 'swamp\_ramets' 'butterfly\_ramets'

Count data of randomly selected milkweed ramets observed throughout the defined plot area for each species of milkweed with an upper limit of 10 milkweed ramets per species to be surveyed for ‘eggs’ and ‘instars’

'eggs' count data of total number of monarch eggs observed, summed across all 0-10 milkweed ramets observed for each specific milkweed species.

‘instar’ count data of total number of monarch instars observed for each of the separate 5 instar stages, summed across all 0-10 milkweed ramets observed for each specific milkweed species.

'palmer\_amaranth'

observed count data of palmer amaranth plants within the plot perimeter. No palmer plants have been observed at any site.

See ‘environment’ data set for 2017 and years following weather data.

**2018 Notes**

Missing data: fis1 all rounds

site eliminated from study due to establishment failure. No more data to be collected.

**All Years Notes:**

Start time is written in xx:xxPM format. No zero in the hour slot if it isn’t 10, 11, or 12. Examples: 9:36AM or 12:28PM

'extra\_monarch' in 2016 or 'extra\_monarchs' in all other years

Observed count data of monarchs seen outside the monitoring time, anywhere at the site. This data exists for all years, all sites.

If 'wind', 'sky', or 'temp' were unfavorable monarch data was not collected:

'NA' was entered for 'start\_time' (and 'end\_time' in 2016)

'NA' was entered for monarch numbers by 'bin' or meter section or 'watch\_monarch'

'stems', 'eggs', and 'instar' data were still collected regardless of weather

General ‘wind’, ‘sky’, ‘temp’ conditions which were considered unfavorable:

Wind: >20mph

Sky: rain

Temp: <65°F or >95°F

**Landscape Protocol**

‘Landscape’ surveyed the area outside the perimeter of the plot to determine if milkweed and flowering plants were present. Physical data sheet also listed ‘type of habitat’ which was outside the plot but this data was too ambiguous to be used so it was not recorded in the Git ‘landscape’ data set. Plot perimeter was not established until round 3 2016 data collection. Round 1/2 landscape surveyed area was at the discretion of the observer as to what was ‘outside’ the plot.

Landscape data only exists for 2016. In 2017 and following years, data collection relating to the outside of the plot is stored in the 'environment' data set. 'environment' data set is very different than 'landscape' 2016 data.

Weather data: Round 1 2016 Weather data which was recorded on the physical ‘landscape’ data sheets was recorded in the Git ‘monarch’ data set and not in the Git ‘landscape’ data set. ‘landscape’ weather data used correct formatting. ‘monarch’ physical data sheet line items were incorrect in round 1 2016. Weather data line items were removed from ‘landscape’ data sheets after round 1 2016. Physical data sheet line items were resolved for ‘monarch’ data set and weather data was recorded in ‘monarch’ data set for round 2 and 3 2016. All 2017 and following years weather data was recorded in ‘environment’ data set and in no other data set.

**2016 Notes (only 2016 data exists)**

Round 1 data

‘direction’

Placeholder. Has no real meaning in round 1. Round 1 data did not include a cardinal direction side of the plot to survey. Survey encompasses all area outside of the plot.

‘general’

Placeholder. Has no real meaning. Serves as a row header for the binary yes/no columns

‘milkweed’

Question is: Are milkweed present? Answer is binary yes/no

‘flowering\_plants’

Question is: Are flowering plants present? Answer is binary yes/no

Round 2/3 data

‘direction’

Header which denotes the cardinal direction side of the plot from which data was collected

‘n’ ‘e’ ‘s’ ‘w’

Indicates which side of the plot data was collected from. North, East, South, West.

‘milkweed’

Question is: Are milkweed present? Answer is binary yes/no

‘flowering\_plants’

Question is: Are flowering plants present? Answer is binary yes/no

Missing data: Data is NA as site did not yet exist.

Round 1: ber3, dun3, bcr1, bcr2, tie1, app1

Round 2: app1

Missing data: Data is NA as transect location was moved.

Round 1: uth3, arm1, nor1

Round 2: nor1

**Environment Protocol**

Environment surveyed the weather at the time of data collection and the area outside the perimeter of the plot to determine milkweed ramet abundance and % ground cover of flowering plants.

Environment data does not exist for 2016. Environment data was collected in 2017 and the years following.

‘temperature’

°F. Measured with an anemometer on site.

‘wind’

Miles per hour. Measured with an anemometer on site.

‘sky’

‘Clear’: no clouds.

‘Mostly clear’: <50% cloud cover

‘Mostly cloudy’: >50% cloud cover

‘Cloudy’: 100% cloud cover

‘Rain’: rain

‘milkweed\_ramet’

Count data of total milkweed ramets of any milkweed species observed within defined banded area around plot perimeter. Band was defined as area which was between 5-25 meters from the plot edges, essentially a ‘frame’ around the plot which had a width of 20 meters wide, starting 5m from the plot edge.

‘currently\_flowering\_plants’

Visually estimated % of land cover which is covered by currently flowering plants within same defined area as ‘milkweed\_ramet’ data collection. A 20 meter wide frame around plot exterior, starting 5m from the plot edge. In essence this data is attempting to do a daubenmire reading for % of cover of flowering plants across a large area.

‘0’: 0% (no flowering plants present in defined area)

‘0-5’: <0-5%

‘25-50’: 25-50%

‘50-75’: 50-75%

’75-100’: 75-100%

‘dominant\_flowering\_species’

Visually estimated evaluation of which flowering species was present at greatest total number of plants inside the 20 meter wide frame around the plot exterior, starting 5m from the plot edge. Observation was recorded by its common name. Common names and corresponding scientific names are recorded in the file ‘nectar\_species\_scientific\_name\_counting\_unit’ located in the folder 'data-raw/nectar' in the Git repository ISUmonarch.

If no flowering species were present (‘currently\_flowering\_plants’ was 0) no data for ‘dominant\_flowering\_species’ is recorded

If multiple species were codominant; multiple species were listed separated by a semicolon

Missing data: funding cut. 2017.

Round 1 2017 data NA (not sampled) for sites under grant 'pork'. pre1a, pre1b, pre2a, pre2b, pre3a, pre3b, pre4a, pre4b, bcr1, bcr2, tie1, app1

Resampled, missing data. 2018.

Cra1 was resampled for 'bee' and 'environment' data 8-30-17 from original date of 8-15-17

Missing data: fis1 all rounds. 2018.

site eliminated from study due to establishment failure. No more data to be collected.

**Nectar**

Nectar plants were surveyed by an observer walking along a permanent transect line. Observer walked a line parallel to the transect at a length of 1.5m to the right of the transect. Observer visually surveyed a 1m wide band along the whole length of the transect, recording every visual detection of a blooming floral resource.

If no nectar plants are present for entry, header is present but no plants are listed.

Transect length

Transect length differed between sites. Transect length ranged from 30 meters to 100 meters in length. See '2016\_survey\_dates\_transect\_lengths', '2017\_survey\_dates\_transect\_lengths', and '2018\_survey\_dates\_transect\_lengths', to determine transect length for each site.

Transect length sometimes differed at the same site across different rounds. See '2016\_survey\_dates\_transect\_lengths', '2017\_survey\_dates\_transect\_lengths', and '2018\_survey\_dates\_transect\_lengths', to determine transect length for each site.

transect length changed as noted in '2016\_survey\_dates\_transect\_lengths' at sites: cre1, nkn1, nkn2, sie1, pre1a

transect length changed at sut2 and pre1a between round 3 2016 and round 1 2017

transect length remained the same at all sites from round 1 2017 and following

Section length

2016- see datasheet or '2016\_survey\_dates\_transect\_lengths' document to determine if sections were 10 meters or 20 meters in length in 2016.

All sections were 10 meter lengths in 2017 and years following

Meter sections

Denotes meter section in which ‘nectar plant species’ occurred

‘Nectar Plant Species’

Plants were identified using a guide developed by Seth Appelgate, based on available online guides.

The floral resource (or nectar plant) was recorded by its common name.

Numbers are count data, counting total number of nectar species counting units for each species by section. If nectar species were present at high densities counting may have been by 5, 10, 20, 50 or other large units.

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‘nectar\_species\_scientific\_name\_counting\_unit’ document contents. Located in the folder 'data-raw/nectar' in the Git repository ISUmonarch.

‘Nectar Plant Species’ common names and corresponding scientific names

‘Nectar Plant Species’ field count unit

Specific to each species. Counting units are either umbel, head, ramet, or spike and are listed in the column ‘field\_count\_unit’.

Classification of plants as either native, introduced, or both as defined by the USDA PLANTS database.

Classification as either planted or non planted. Indicating which species were in the native seed mix planted.

**2017 and Years Following Notes**

‘common\_milkweed\_ramet’ ‘swamp\_milkweed\_ramet’ ‘butterfly\_milkweed\_ramet’

count data of milkweed ramets for each milkweed species within the 1m wide sampling area. Milkweed ramet was counted regardless of whether or not it was flowering.

Survey is not technically a part of the ‘nectar’ survey but was included on the data sheet for because area covered was exact same as ‘nectar’ data

Length of transect as noted in '2016\_survey\_dates\_transect\_lengths', '2017\_survey\_dates\_transect\_lengths', and '2018\_survey\_dates\_transect\_lengths' can be used to calculate area surveyed. Area surveyed/detected milkweed ramets = milkweed ramet density for each species.

‘milkweed strip: common milkweed ramet’

Count data of common milkweed ramets observed in 1m strip along edge of plot

Only at sites: all2 (north edge), arm1 (south edge), ber3 (east edge), nkn1 (south edge)

Milkweed strip was a 1m wide strip that ran the length of the plot where only common milkweed was planted.

**Missing Data**

2016

Missing data: Data is NA as site did not yet exist.

Round 1: ber3, dun3, bcr1, bcr2, tie1, app1

Round 2: app1

Missing data: Data is NA as transect location was moved.

Round 1: uth3, arm1, nor1

Round 2: nor1

2017

Missing data: funding cut.

Round 1 2017 data NA (not sampled) for sites under grant 'pork'. pre1a, pre1b, pre2a, pre2b, pre3a, pre3b, pre4a, pre4b, bcr1, bcr2, tie1, app1

2018

Resampled, missing data.

Cra1 was resampled for 'bee' and 'environment' data 8-30-17 from original date of 8-15-17

Missing data: fis1 all rounds. 2018.

site eliminated from study due to establishment failure. No more data to be collected.

**Daubenmire Survey**

Daubenmire and robel data share the same directory and are both saved with the same file name except that robel data is saved with a '2' after the .csv extension.

site\_transect\_round.csv2

Daubenmire survey was done at 10m lengths along a permanent transect line. Observer placed a quadrant (1 meter x 0.5m rectangle) on the left side of the transect. Quadrant was placed with 1 meter edge perpendicular to the 100m tape and 0.5 meter edge extending from transect point to 0.5 meters along transect length. Observations started at 0 meters on the transect and were taken every 10m of the transect. Observations were at a point on the transect and did not encompass the full length of a section. Data collection began at 0 meter starting point of the transect and stopped before the transect ended. A transect length of 100m will have points recorded for 0 meters through 90 meters; 10 points. Data is not taken at the final point on the transect as this area is outside the transect.

**Daubenmire**

‘section’

Denotes the point along the transect at which the observation was made.

‘csg’ ‘wsg’ ‘forbs’ ‘milkweed’ ‘woody\_species’ ‘bare\_ground’ ‘leaf\_litter’

All values are percentages. Data points represent a daubenmire coverage class based off Daubenmire 1959. Observer looks from a top-down/birds eye view and estimates the area of the frame the specific plant material covers. Due to cover existing at different heights with potential for overlap, total percent cover of all cover classes combined can be greater than 100%. Example: quadrant could potentially have 16% WSG, 86% CSG, 38% forbs, 16% milkweed, 3% woody vegetation, 16% bare ground, and 38% leaf litter. When these percentages are added together, they exceed 100%. (A milkweed could be covering 16% of the frame and still have grasses taking up area underneath it.)

Daubenmire coverage classes: 0 - absent, 1 - trace, 3 - trace-5%, 16 - 5%-25%, 38 - 25%-50%, 63 - 50%-75%, 86 - 75%-95%, 98 - 95%-100%

‘csg’

Cool season grass. Includes sedges and equisetum. Does not differentiate between native and non-native species.

‘wsg’

Warm season grass. Does not differentiate between native and non-native species.

‘forbs’

All non-grass herbaceous plants. Does not include milkweed. Does not differentiate between native and non-native species.

‘milkweed’

Milkweed of any species

‘common\_ramet’, ‘swamp\_ramet’, ‘butterfly\_ramet’

Count data, not % daubenmire coverage class. Total number of milkweed ramets by their species.

‘woody species’

Trees or shrubs

‘bare ground’

Soil surface which is not covered with leaf litter, residue, or stems. Includes tree roots, stumps, animal manure, and mushrooms.

‘leaf litter’

All horizontal dead plant material that is no longer rooted: twigs, leaves, grass.

‘litter depth’

Depth of horizontal dead plant material on the soil surface in cm. Value is not a %**.**

2016

Variables included: ‘csg’ ‘wsg’ ‘forbs’ ‘milkweed’ ‘woody\_species’ ‘bare\_ground’ ‘leaf\_litter’ ‘litter depth’

2017 and years following

Variables added: ‘common\_ramet’, ‘swamp\_ramet’, ‘butterfly\_ramet’

**Robel**

Robel survey is a visual obstruction survey of standing vegetative material. Robel survey was done at 10m lengths along a permanent transect line. Observer placed a robel pole on the left side of the transect. Our robel pole was marked with bands every 10cm starting at a value of ‘1’. 0-10cm is 1. Pole was 160cm tall or a value of ‘16’. Observer crouched at a distance of 4 meters from the pole and at a height of 1 meter above the ground. A robel reading was taken in all 4 cardinal directions (N,E,S,W). Robel reading is the highest band (10cm section) on the pole at which vegetation obscures ≥50% of the band on the pole when vegetation obscures ≤50% of the band above it on the pole. Example: “4” is barely visible but “5” is unobscured, the reading is 4. Visual obstruction readings are allowed to be zero.

Observations started at 0 meters on the transect and were taken every 10m of the transect and stopped before the transect ended. A transect length of 100m will have points recorded for 0 meters through 90 meters; 10 points. Data is not taken at the final point on the transect as this area is outside the transect.

‘direction’

Denotes the cardinal direction from which the data was taken.

‘n’, ‘e’, ‘s’, ‘w’

Denotes the cardinal direction from which the data was taken. Directions are based on the observer’s position in relation to the pole, not the direction in which the observer is looking. Example: ‘n’ data is taken by the observer when the observer is north of the pole looking south.

**Survey**

Files are organized by survey year.

'survey2016' 'survey2017' 'survey 2018' contain site and survey specific information.

Each line represents an individual survey at a site

If site did not yet exist at time of survey the site is not listed for that year/round.

'transectID'

unique site identifier. Each site has only 1 transect.

'year'

year in which the data was collected at the site

'round'

round in which the data was collected at the site. 3 rounds exist for all sites unless site did not yet exist or data was not collected.

'length'

transect length in meters

'section\_length'

length of section. Length of section is always 10 meters in 2017 and years following. Length of section in 2016 was sometimes 20 meters and sometimes 10 meters. This issue affects 2016 'bee' 'monarch' and 'nectar' data.

'area'

area in meters squared of the plot at the time of survey. Area occasionally varied due to plot length or edge changes.

'monarch\_time'

length of time in minutes for which monarchs were observed and recorded at the site. Observers were supposed to walk the transect at a speed of 2 minutes/10m section (which they did correctly). For round 1/2 of 2016 only, if the transect was shorter than 100m they were supposed to continue to observe at the end of the transect while stationary until reaching a total of 20 minutes of survey time. This stationary observation only occurred if the site was shorter than 100m and the observer completed a 20 minute survey as they were supposed to. This stationary observation did not occur if the observer erred and stopped collecting data at the end of the transect, having not reached 20 minutes of total observation time. These errors resulted in observation times shorter than 20 minutes, as is detailed in the file ‘2016\_survey\_dates\_transect\_length’ or 'survey2016'. Observations in 2017 and years following were always 20 minutes.

**Metadata**

'Data Sheet Observer Names' file contains the official observer names used within the file directory. Names consist of first name and last initial; first letter of first name is capitalized and last letter of last name is capitalized.

'Site Info Metadata' contains site specific notes which are unlikely to be used in statistical analysis.