APPENDIX 1-8. Determination of Overlap of Likely thiamethoxam Exposure Area and Species Ranges and Critical Habitat for Species Located Outside of the 48 Contiguous States (NL48)

The overlap extent of thiamethoxam’s likely exposure areas and the range (or critical habitat) of a species integrates information on potential use sites and usage data. This approach considers overlap of the species range (or critical habitat) with areas directly treated with thiamethoxam and those receiving spray drift, as well as a poultry litter layer that accounts for thiamethoxam-treated poultry litter that is used as soil amendments to agricultural fields. To address uncertainties associated with how treated acres may be distributed within a state (relative to a species range or critical habitat), and the magnitude of usage on any given year, approaches are employed to represent a central estimate of overlap as well as upper and lower bounds. These different estimates are considered in the Weight of Evidence when deciding whether use of thiamethoxam is likely or not likely to adversely affect (LAA or NLAA) an individual of an assessed species. The estimated overlap extent of the likely exposure area and species range (or critical habitat) is used in Step 2 as a surrogate for the percent of the listed population that could be exposed to thiamethoxam. Additional details are provided in the Revised Method[[1]](#footnote-2) document. This appendix describes the approach for determining the extent of overlap outside of the 48 Contiguous States (represented by non-lower 48 states and abbreviated with NL48).

Outside of the 48 contiguous states (NL48), usage data relevant to thiamethoxam are only available for Hawaii and Puerto Rico. In Alaska, the Commonwealth of the Northern Mariana Islands, Guam, America Samoa and the US Virgin Island usage is assumed to be 100% for agricultural use sites and a surrogate is used for non-agricultural use sites. Aggregated PCTs in Alaska may be less than 100% after accounting for unregistered crops using the Census of Agriculture, see **Section 2.1**.

1. Potential Use Sites

The landcovers representing potential thiamethoxam use sites in Hawaii, Puerto Rico, Commonwealth of the Northern Mariana Islands, Guam, America Samoa and the United States Virgin Islands include the following:

* 1. Agriculture
	2. Nurseries (Field Nurseries)
	3. Developed
	4. Open Space Developed
	5. Managed Forests (Christmas Trees)
	6. Poultry litter
1. Applying Usage Data to UDLs

To account for thiamethoxam is registered for all these use sites, this method considers all these potential use sites and relevant usage data. The sections below discuss the usage data available for each potential use site. As part of the Weight of Evidence analysis, maximum, average and minimum assumptions regarding the amount of usage are considered with different distributions of the treated acres. Landcover is available in Alaska but is not included because species are not assessed quantitatively. **APPENDIX 1-6** provides a thiamethoxam specific crosswalk across crop data sources for thiamethoxam uses.

## Agriculture and Pasture/Rangeland

Pesticide usage data are collected for Hawaii and Puerto Rico as part of USDA’s Census of Agriculture (CoA). Data are reported as broad categories, *i.e.,* insecticide, herbicide and fungicide. Although these data are not pesticide specific, they are useful in defining the proportion of agricultural areas where insecticides may be applied. In the future, when the landcover data representing the potential use sites are updated to account for the new census, the usage data will also be updated. Regardless of the year that is used, the assumption that the usage data for all insecticides represents usage of thiamethoxam is conservative.

The CoA data reports the number of acres of agriculture that were treated for insect pests. **Table 1** includes the total cropland acres treated with insecticides and the total cropland acres that were reported in the 2012 census. These values were used to derive percent crop treated (PCT) values for potential use sites represented by agriculture located in Hawaii (12.7%) and Puerto Rico (8.1%). This approach is conservative and overrepresents the usage of a single active ingredient because it assumes that all applications of insecticides (which include multiple active ingredients) are represented only by thiamethoxam. These values are further refined by accounting for unregistered grown in the regions when calculated the aggregated PCTs. Unregistered cannot be treated and therefore are given a PCT of 0%, all registered crops received the all insecticide PCT. For Alaska, usage data is unavailable, registered crops receive a PCT of 100% and unregistered crops receive a PCT of 0%. The results aggregated PCT is 61%.

**Table 1. 2012 CoA data for acres treated with insecticide and total acres grown of crop in Hawaii (HI) and Puerto Rico (PR)**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Use** | **Location** | **Acres treated\*** | **Total acres\*** | **PCT** | **Aggregated PCT** |
| Agriculture | HI | 30,417 | 174,042 | 18% | 13% |
| PR | 45,989 | 421,043 | 11% | 8% |
|  | AK | -- | -- | 100 | 61% |

\*From 2012 census

No pesticide-specific or general insecticide usage data are available for any of the other US territories where federally listed species occur, and there is no available reliable surrogate to allow for a reliable estimate of usage in other territories at this time. Therefore, usage data will not be considered for territories other than Puerto Rico. When no usage data are applied, to overlap of potential use sites and species ranges represents an overestimate of the area where individuals of a listed species are expected to be exposed thiamethoxam.

## Non-Agricultural Uses

Non-agricultural national level usage data for the contiguous United States (ConUS) are available in the SUUM (**APPENDIX 1-4;** see **Table 3** in the SUUM**).** The usage information can be available as treated area based on survey data or reported as average pound applied for the use.Similar to the agricultural uses, if a single UDL represents multiple use sites found in the SUUM these usage data are aggregated into aggregated PCTs.

If information on treatable acres, base acres treated for all insecticide and/or treated acres for thiamethoxam is available from the market research survey data this information is used in the calculation of the non-agricultural PCTs. Treated acres specific to thiamethoxam usage not available for many non-agricultural use sites but when available this information is used in the calculation of non-agricultural maximum and/or average PCT. When base acres treated is available, the maximum PCT is based on the ratio of base acres treated with thiamethoxam to the total treatable acres for the non-agricultural use (**Equation 1-1**). And the average aggregated PCT is based on the ratio of acres treated with thiamethoxam to the total treatable acres (**Equation 1-2**). If the base aces treated is not available but the treated area for thiamethoxam is then this information is used to calculate the maximum aggregated PCT (**Equation 1-2**).

**Equation 1-1.**

Where:

|  |  |
| --- | --- |
| Acres treated chem classes = |  Acres treated for the chemical class based on survey information. |
| Total Treatable Acres= |  Total treatable area for uses based on survey information  |
| PCT max = | Calculated maximum PCT |

**Equation 1-2.**

Where:

|  |  |
| --- | --- |
| Acres treated chem classes = |  Acres treated for the chemical class based on survey information. |
| Total Treatable Acres= |  Total treatable area for uses based on survey information  |
| PCT max or avg = | Calculated maximum or average PCT |

When base and/or chemical treated acres is unavailable in the survey information related, estimates of treated area are calculated based on the avg. annual pounds active ingredient (a.i.) applied, minimum max label rate, and maximum label rate found in the SUUM (**Equation 2-1, 2-2, 2-3**). In this situation, the maximum estimated treated acres are equal to the average reported annual pounds a.i. applied divided by the minimum max labeled application rate. The average number of treated acres is estimated by taking the number of average reported pounds applied and dividing by ½ of the maximum labeled application plus the minimum max labeled application rate. The minimum is generated by dividing the average reported pounds applied divided by the maximum labeled application rate. For thiamethoxam this method for estimating treated is only need for the average and minimum PCTs. If usage data is unavailable a PCT of 100% is used.

**Equation 2-1**.

Where:

|  |  |
| --- | --- |
| Acres treated chem = |  Acreage that is treated  |
| Total Treatable Acres = |  land cover class |
| PCT avg = | Calculated average PCT |

**Equation 2-2**.

Where:

|  |  |
| --- | --- |
| Annual pounds AI applied avg = |  Annual average pounds applied of Active Ingredient  |
| Label Ratemin= |  Minimum application rate for the chemical in the SUUM (lb ai/a) |
| Treated Acresmax = |  Estimated maximum treated acres based on label rates |

**Equation 2-3**.

Where:

|  |  |
| --- | --- |
| Annual pounds AI applied avg = |  Annual average pounds applied of Active Ingredient  |
| Label Rate min= |  Minimum application rate for the chemical in the SUUM (lb ai/a) |
|  Label Rate max = |  Maximum application rate for the chemical in the SUUM (lb ai/a)  |
| Treated Acres avg = |  Estimated maximum treated acres based on label rates |

After calculating the estimated maximum, average and minimum treated acres based on the above methods, the associated aggregated PCTs equals the treated acres are divided by total treatable acres reported in the SUUM when available, or the estimated treatable acres based on the area found in the UDL if the total treatable acres is not reported in the SUUM **(Equation 3)**.

**Equation 3**.

Where:

|  |  |
| --- | --- |
| i = | PCT Estimate, max, avg, or min |
| Treated Acres= | Estimated treated acres |
| Total Treatable Acres= | Total treated acres as reported in the SUUM or estimated based on the UDL |

Due to limited non-agricultural usage data for thiamethoxam, most uses were assumed to have 100% PCT, but when data was available this was refined, and the lower limit PCT of 2.5% when no usage was reported.

Due to the uncertainty in estimating the treated acres based on application rates, if a minimum PCT results in a value greater than the average, the minimum PCT is set equal to the average. The following sections provides additional information for each use sites based the corresponding UDL.

## Managed Forest (Christmas Trees)

For NL 48 thiamethoxam ornamentals (Christmas tree plantations) was cross walked to managed forests, and usage specific to managed forests is not available. For this reason, 100% PCT was assumed, with acre estimates from the managed forest UDL for the NL 48.

## Developed

For thiamethoxam ornamentals (residential/commercial landscapes) were cross walked into developed, and usage specific to developed is not available. For this reason, 100% PCT was assumed, with acre estimates from the developed UDL for the NL48.

## Nurseries (Field Nurseries)

For thiamethoxam ornamentals (field nurseries) were cross walked into nurseries (field nurseries), and usage specific to field nurseries is not available. For this reason, 100% PCT was assumed, with acre estimates from the nurseries UDL for the NL48. Further refinement may be considered in the final thiamethoxam BE assessment.

## Open space developed

When considering the available usage data for open space developed uses of clothianidin, the majority of registered uses are not surveyed at the national level and include, ornamentals, lawns, golf courses and sod farms. Pounds applied for these uses are not available and therefore 100% PCT used, with acre estimates from the open spaced developed UDL for the NL48.

## Poultry Litter

Poultry litter is assumed to be applied to the corn, soybeans, other grains, cotton, wheat, rice, other row crops, vegetables and ground fruit and alfalfa use data layers (UDLs). In the NL48 all crops are represented using the Agricultural UDL, and it was used for the poultry litter layer. Kellog *et al.* (2000) identified 24 crops reported in for manure/litter application based on the assimilative capacity (or land application capacity). The Agricultural UDL in the NL48 is the footprint for the poultry litter is likely to be used was generated then limited to the counties identified with potential poultry operations using the USDA National Agricultural Statistics Service (USDA-NASS). The USDA-NASS collects data on livestock and poultry production in the United States through its ongoing survey programs as well as through the Census of Agriculture conducted every five years.

The poultry inventory data only includes turkey, rooster, broiler and layer inventories. Whereas, poultry operations with inventory data includes total poultry operations. Data with “withheld to avoid disclosing data for individual operations (data with D abbreviations)” was included to determine spatial footprint. Counties with no data probably contain developed area and have lesser chance to have poultry operations. But to be conservative and consistent with other agricultural use processing, these no data counties were also included to determine spatial footprint. These yield an entire national level poultry spatial footprint. Drift is not included with this UDL.

Uncertainties in this layer included using all of the 24 potential crops recommended by Kellog *et al.* (2000)for litter application, and assuming application to all fields.  Each of these included crops are treated equally and does not consider other potential factors that impact litter application to the land such as crop specific application rate.  Applications to corn and other grasses will have the highest application rates, which lower the number of acres to assimilate the poultry litter. Other cropland sites, such as soybean and alfalfa require very less application rates due to their nitrogen fixing abilities, and the inclusion of these crops equally increases the number of acres in the litter layer. Litter application rates for the nitrogen fixing crops are likely very low and it will be mainly based on the phosphorus needs of the crop.

Usage data is not available for this use and a PCT of 100% is assumed.

1. Calculation of Extent of Direct Overlap of Species Range or Critical Habitat and Treated Acres

The aggregate PCT is used to calculate the total number of acres treated within a state for each UDL (PCT x total acres within a UDL = total acres treated for a UDL). The approach described above combines data that are at different spatial scales, *i.e.,* 30-meter pixel, county and state, for UDLs, Census of Agriculture and usage, respectively. Because of the differences in scales, the usage of thiamethoxam can be limited to county and sub-county areas representing potential use sites; however, the actual location of the treated acres within the state is unknown.

Three different assumptions are employed to represent how the treated acres are attributed to potential use site acres within the species range (or critical habitat): upper bound (concentrated within the species range), uniform distribution, and lower bound (concentrated outside of species range). Each of these approaches are discussed below. In all three approaches the estimated treated area within the species range (or critical habitat) is used to calculate the direct overlap of treated sites and the species range (or critical habitat). Direct overlap is equal to the total treated area within the species range divided by the total area of the species range (or critical habitat).

The upper bound approach assumes that all the treated acres in a state occur within the species range (or critical habitat) to the greatest extent possible. In this approach, the total acres treated for the state are calculated using the aggregated PCTs. The total treated acres for the state are compared to the total number of acres within a species’ range that overlaps with that UDL. If the number of treated acres in a state is greater than the number of acres in the UDL that overlap the species range, it will be assumed that all acres within the species range that overlap with the UDL are treated, with the excess treated acres assumed to occur outside of the species range. As described above, treated acres are only placed in counties within the species range where at least 1 registered labeled use for the UDL occurs, as identified by Census of Agriculture. If the number of treated acres is less than the total number of UDL acres that overlap with the species’ range, then it is assumed that all treated acres for the state in that UDL occur inside of the range of a species.

For the uniform distribution approach, the aggregated PCT is applied directly to the acres of the UDL occurring within the species range or critical habitat to calculate the estimated treated acres. This approach assumes that the treated acres are distributed uniformly throughout the state.

The lower bound approach is essentially the opposite of the upper bound. In the lower bound approach, it is assumed that the treated acres are distributed outside of the species range to the greatest extent possible. The total acres treated for the state are compared to the total number of acres outside of a species’ range for the UDL. If the number of treated acres in a state is greater than the number of acres of UDL outside of the species range, it will be assumed that all acres outside the species range are treated, with the excess treated acres assumed to occur within the species range. If the number of treated acres is less than those outside of the species’ range, it is assumed that all treated acres for the state in that UDL occur outside of the range of a species.

When a species range spans multiple states, the uniform, upper, and lower bound approaches are individually applied to each state relevant to a species. The treated acres across all pertinent states are summed to calculate the number of treated acres overlapping with the whole species range (or critical habitat).

The calculation of total treated area based on the temporally aggregated UDLs likely overestimates the area where crops could be found on the same land in a given year and is a conservatism in the process. The upper bound method, which concentrates all the treated acres in the species range (or critical habitat), frequently results in more treated area for a given state than expected when considering all cropped acres in the state. Additional assumptions and uncertainties related to this the calculation of total treated acres and the distributions of the treated acres related to the species range (or critical habitat) are presented in the Revised Method**.**

1. Calculation of Composite Drift Layer Overlapping with Species Range or Critical Habitat

When the action area is derived, each relevant UDL is combined into a composite layer representing all potential uses. The composite layer is generated by placing all relevant UDLs on top of each other, the merging the together to set the footprint for the pesticide as a single layer. This composite layer is then buffered out in all directions based on the application method with the greatest drift potential for the pesticide. For thiamethoxam this is the aerial application, resulting in a maximum buffer distance of 2600 ft, or approximately 792 meters. For an individual species, the composite drift area is then refined by considering only the uses with overlap when applying the maximum buffer for the pesticide. The specific application methods and rates relevant to these uses and the species-specific endpoints that result in the farthest distance from the treated field, where effects may occur, are used to determine the extent of the composite drift layer for that species.

When usage data are considered, it is necessary to account for a decrease in the extent of areas receiving spray drift because the treated area has deceased. The total possible area receiving drift is based on all potential use site found in the action area. Prior to applying usage, drift in all directions is calculated. After applying usage only, a portion of potential use sites in the action area will be treated, changing the drift extent.

Since the actual location of the treated acres within a state is unknown, specific areas are not buffered in the Step 2 approach. To account for the reduction in actual acres treated, a factor is applied to this composite drift area based on a state aggregated PCT for all of the uses combined. Additionally, a factor is applied to account for the distribution of theses acres under an upper bound (maximum acres within the species range), lower bound (maximum acres outside the species range) or uniformly distributed within the range as previously discussed. The distribution of acres within the state relative to the species range will also affect the impact of spray drift. For the upper bound scenario, no additional factor is applied to the aggregated PCT, but for the uniform and minimum scenarios, the ratio of the number of treated acres calculated for the uniform or lower bound scenario to the upper bound scenario is applied to the PCT. Lastly, to account for the uncertainty in the true spatial distribution of the use sites, as well as the uncertainty of multiple sites potentially impacting the same locations, the adjusted PCT value is rounded up to the nearest ten place value (*e.g.,* factor of 0.056 is rounded to 0.1). This composite factor is used to scale the number of acres impacted by off-site drift and subsequently lower the total predicted overlap with a species range or critical habitat due to drift.

Another factor often discussed for consideration in spray drift is the impact of wind direction on off-site transport for species ranges that are impacted by spray drift occurring in all directions. Methods have been proposed in the past to account for this, including the use of wind rose plots to better predict off-site movement of a pesticide. As a simplified method to account for the impacts of wind direction, an additional factor is applied to spray drift based on the number of applications that can occur for the use patterns that are relevant to a species. For the composite factor determined above, a wind direction scaling factor is applied where the factor is scaled to 25% for each application allowed, to represent movement of a pesticide off-site in only one direction, or essentially ¼ of a circle when one application is made. More specifically, if only one yearly application is allowed for the relevant use sites, a factor of 0.25 is applied, if 2 applications are allowed, a factor of 0.5, if 3 applications are allowed, a factor of 0.75 and if 4 or more applications are allowed, a factor of 1 (or no additional scaling is applied). The equations used to scale the spray drift overlap are provided below in **Equation 4** and **Equation 5**.

**Equation 4**.

**Equation 5**.

In summary, the number of acres in a species range (or critical habitat) potentially exposed due to spray drift is calculated using the equations above for each state. This total number of acres is then divided by the total acres in the species range to determine the overlap area due to drift. For predicting relative EECs in the drift zone, the number of acres are further refined to how many are in each 30 meter increment off-site; start at 30 meters and continuing to 792 meters off-site or the limit aerial drift. Additional uncertainties and conservatism of the method for applying usage data to drift are provided in the Revised Method.

1. Determination of Overlap of Exposure Area and Species Range or Critical Habitat

To determine the total overlap exposure area, the total number of treated acres within the species range (direct overlap) are added to the scaled number of acres receiving spray drift then divided by the total number of acres of the species range (or critical habitat). This can be considered the percent of the species range/habitat that is likely to be exposed to the pesticide of interest, based on usage data and predicted spray drift. For species whose life history information indicates the species will not utilize the potential use site areas, overlap of direct treated sites will be zero for direct exposure and only the scaled areas receiving spray drift are considered for the species overlap.

There are 5 different overlap scenarios generated for consideration. The first represents the unadjusted or pesticide usage independent overlap, the 2nd and 3rd incorporate the chemical specific usage information and accounts for the redundancy in the UDL layers, and the 4th and 5th incorporate species life history information by removing direct overlap if the species will not utilize the potential use site and limiting the overlap extent to just the areas represented by suitable habitat. These 5 overlap scenarios are discussed in more detail in the following section.

When considering the three different assumptions related to distribution of treated acres relative to species range (*i.e.,* concentrated in species range (upper), uniform throughout state (uniform) and concentrated outside of species range (lower)) and the three different assumptions regarding the amount of usage on a given year (*i.e.,* maximum, average or minimum annual PCT), there are 9 different estimates of the overlap of the species range (or critical habitat) and the exposure area for each overlap scenario. The overlap estimates for pertinent scenarios are considered in addition to the influence of using surrogate usage data when none are available as part of the Weight of Evidence. This information is considered in the Weight of Evidence to determine the likelihood that an individual will be exposed and adversely affected.

1. Background - Spatial Co-occurrence of Species Location and Potential Use Sites

The co-occurrence analysis identifies if a species range (or critical habitat) and UDL overlap, and if so by how much. Required inputs to conducting the co-occurrence analysis include a list of species, species location files, pesticide Use Data Layers (UDLs), and any additional supporting species life history information used to supplement the analysis. The species list needs to include all species and designated critical habitat subjects to section 7 of the Endangered Species Act. Location files for each species range and critical habitat need to be accounted for prior to use in the co-occurrence analysis. The pesticide Use Data Layers (UDLs) representing each label use also need to be accounted for prior to completing the analysis. Finally, any additional species life history or spatial datasets, (*e.g.,* GAP/Landfire habitat layer) used to supplement the co-occurrence analysis need to be identified. Additional detail on these spatial inputs and the tools use to generated them can be found with the BE models/tools.

All inputs are finalized and standardized using the Co-occurrence Inputs-Species/Use and Supporting Tables tool. The co-occurrence analysis leverages the ArcGIS Tabulate Area tool, executed as a batch using Chemical Independent Co-occurrence Results-Parent Use Overlap Tables tool. The Chemical Dependent Co-occurrence Results-MAGtool Tables tool generates the standard output tables summarized by UDL and species used in the BE, incorporating usage and species life information into the results. The five different overlap scenarios are generated as output from this tool. Additional information on each of these tools can be found with the respective tool documentation.

The first overlap scenario provides a usage independent overlap, without any adjustments to account for usage or species life history. The remaining overlap scenarios apply usage and species information to the overlap. First the aggregated PCTs for thiamethoxam, described above, are applied to the species/UDL overlap using the three different distribution methods for the treated acres. Following the application of usage information, results are scaled to account for the redundancy in the UDLs. Additional detail on the method for applying the redundancy scaling factors is provided below. The last two overlap scenarios account for species life history information. First, if the species will not utilize the potential use site directly the overlap representing the direct overlap is excluded, limiting the results to the areas of drift overlap. Lastly, if the species is more likely to use certain habitats this can be considered by limiting the extent of overlap to just the areas of the species range with those habitats. This suitable habitat consideration is not applicable to designated critical habitat and is considered in conjunction with the results representing the full range as part of the Weight of Evidence.

1. Input Data Used for Co-occurrence Analysis

## Master Species List

Species subject to section 7 under the Endangered Species Act are obtained from the US Fish and Wildlife Threatened and Endangered Species System[[2]](#footnote-3) (TESS). The resulting table is filtered to include listing statuses[[3]](#footnote-4) currently subject to section 7 or potentially subject to section 7 during the registration time period. Information from TESS for species under the jurisdiction of the National Marine Fisheries Service (NMFS) is supplemented with information from the NMFS website[[4]](#footnote-5), deferring to the NMFS website if conflicts exist between the sources. The species list used for this assessment was generated in November 2020.

## Species Locations

The FWS ECOS Portal (<http://ecos.fws.gov>) houses spatial data that represents species’ ranges and designated critical habitat[[5]](#footnote-6). Managed by the species experts and therefore considered the best available information for section 7 consultation, the co-occurrence analysis utilizing this information. The ECOS Portal points users to NMFS websites to access spatial information for species under NMFS jurisdiction not found on the ECOS website. For NMFS species not found in either location a request was made directly to the NMFS scientists. The last download of the species locations occurred in November 2020.

After accounting for each species, the input files used for the co-occurrence analysis are generated with the ESRI ArcGIS Union Toolbox[[6]](#footnote-7). The union tool generates the geometric union of the species files and their attributes presented as non-overlapping ‘zones’. Each unique zone may be occupied by multiple species. The species found in each zone are tracked in a look-up table generated at the time of the union. By using these non-overlapping ‘zones’ a given location is only run once in the analysis, rather than for each overlapping species.

Additional information on this process can be found with the Co-occurrence Inputs-Species/Use and Supporting Tables tool.

## Use Data Layers (UDLs)

The data and process to generate the Use Data Layers is described in **APPENDIX 1-5 and APPENDIX 1-6.**

## Other Inputs

In addition to the usage data described above, species life history information can be considered. Species life history information is incorporated into two of the overlap scenarios. The first considers if the species will be found on potential use sites or exclusively off the use sites. Off use site determinations were made based on species documentation generated by the Services (*e.g.*, Recovery Plan, 5-year Reviews). These determinations were reviewed and updated based on feedback provided by US Fish and Wildlife Service in the Fall of 2019[[7]](#footnote-8). The second scenario was a proof of concept and considers if a species is found exclusively in specific habitats. For this scenario coastal beach habitat was exacted from the GAP/Landfire layer[[8]](#footnote-9) and used to supplement the overlap for obligate coastal beach species found in ConUS. This final scenario is not currently applicable to the non-contiguous United States.

All spatial files, UDLs, species, and supplemental information, are standardized into the selected regional projections prior to use in the co-occurrence analysis. The regions found in the non-contiguous United States under U.S jurisdiction are represented by 5 projected coordinate systems; selected to preserve area calculations. Each one is specific to a region with the exception of Guam and the Commonwealth of the Northern Mariana Islands that share the same projection (**Table 2**).

Table 2. Regional projections used for all spatial files, UDLs and species input files

|  |  |
| --- | --- |
| **Region** | **Projections** |
| Hawaii (HI) | NAD\_1983\_UTM\_Zone\_4N.prj |
| Alaska (AK) | WGS\_1984\_Albers.prj |
| Puerto Rico (PR) | Albers\_Conical\_Equal\_Area.prj |
| United States Virgin Islands (VI) | WGS\_1984\_UTM\_Zone\_20N.prj |
| American Samoa (AS) | WGS\_1984\_UTM\_Zone\_2S.prj |
| Guam (GU) and Commonwealth of the Northern Mariana (CNMI) | WGS\_1984\_UTM\_Zone\_55N.prj |

1. Co-occurrence Analysis

The co-occurrence analysis uses the ArcGIS Tabulate Area tool, executed as a batch with the Chemical Independent Co-occurrence Results-Parent Use Overlap Tables tool. Additional information on this tool can be found with the tool documentation. As described above, the species input files used for the co-occurrence are generated by ESRI ArcGIS Union Toolbox, which creates a series of non-overlapping ‘zones’. Each unique zone may be occupied by multiple species. **Figure 1** provides an example species range, and the same range broken up into the non-overlapping ‘zones’ used as the species input file.

In order apply the usage information the state and county boundaries are added to the species input files using the ESRI Intersect Toolbox. The final ‘zones’ allow for the overlap of a UDL to be reported out by species for a given county or state. The state and county breaks allow for the application of the usage data. The total overlap for each county and state is also calculated so the treated acres for the state can be calculated for the upper and lower distributions of treated acres described above.



**Figure 1. Example of species range represented by zones used as the input for the co-occurrence analysis**

## Overlap Scenarios

Five different overlap scenarios are generated for consideration in the Weight of Evidence. The first is chemical independent and provides results for the species with no adjustment to the overlap. This is followed by incorporating the usage data, scaling for redundancy of the UDLs, and then adding species life history information to the overlap results.

Five different overlap scenarios are generated for consideration in the Weight of Evidence. The first is usage independent and provides results for the species with no adjustment to the overlap. This is followed by incorporating the usage data, scaling for redundancy of the UDLs, and then adding species life history information to the overlap results.

Applying the usage method described above, the aggregated PCTs are applied to the state and county results to calculate the total treated acres for the state. This information is used for the upper and lower distribution of the treated acres. The treated acres are concentrated within the species range (or critical habitat) and the given state for the upper distribution or outside the species range (or critical habitat) and within the given state for the lower distribution. For the uniform distribution, the aggregated PCTs are applied directly to the species results, broken down for a species in a given county and state. After calculating the treated acres for each state within the species range (or critical habitat), all states are summed to get the total treated acres for the species. This process is completed for all UDLs and each of the aggregated PCTs; minimum, maximum and average. The five overlap scenarios are:

* Overlap Scenario 1: No Usage
* Overlap Scenario 2: PCT Overlap
* Overlap Scenario 3:PCT and Redundancy
* Overlap Scenario 4:PCT, Redundancy, Off-site
* Overlap Scenario 5: PCT, Redundancy, Off-site, Habitat

## Scaling for Redundancy in the UDLs

Many UDLs overlap with each other, identifying a single location as multiple potential uses sites, causing the sum of the individual acres in the UDLs to be greater than the acres in the action area, and often greater than the 100% of the species range (or critical habitat). If each UDL was independent the sum of the UDLs would equal the action area. To account for this redundancy between use sites three different factors are applied to results for the individual UDLs; the composite factor, the agricultural factor and the non-agricultural factor.

In order to calculate the composite factor, an agricultural composite containing all agricultural UDLs and a non-agricultural composite containing all non-agricultural UDLs are generated. The composite factor is equal to the sum of the agricultural and non-agricultural composite divided by the action area. This factor accounts for the redundancy between the agricultural and non-agricultural uses. If all uses are independent the sum of the two composites would equal the action area, and the factor would be equal to 1. Each individual UDL is divided by this composite factor.

An agricultural factor is calculated by summing the results of all the agricultural UDLs and dividing by the agricultural composite. This factor is applied to all of the agricultural UDLs to account for the redundancy between agricultural UDLs. Similarly, a non-agricultural factor is calculated by summing the results of all the non-agricultural UDLs and dividing by the non-agricultural composite. This factor is applied to all of the non-agricultural UDLs to account for the redundancy between non-agricultural UDLs. If all uses are independent the sum of the individual UDLs would equal the composite, and the factor would be equal to 1.

After scaling the results to account for redundancy the sum of the individual UDLs will not exceed the action area percent overlap. Equations used in the calculation of these factors are shown below in **Equations 6-8**.

**Equation 6**.

**Equation 7**.

Where:

|  |  |
| --- | --- |
| i = | Agricultural UDLs  |
| n= | Number of agricultural UDLs  |
| j = | Agricultural composite layer |
| PO =  | Unadjusted percent overlap |

**Equation 8**.

Where:

|  |  |
| --- | --- |
| i = | Non-agricultural UDLs |
| n= | Number of non-agricultural UDLs  |
| j = | Non-agricultural composite layer |
| PO =  | Unadjusted percent overlap |

1. Results Co-occurrence Analysis

The final results of the co-occurrence analysis provide the percent of the species range (or critical habitat) that overlaps with each UDL. This metric is provided for each of the overlap scenario. The mean percent overlap and standard deviation for the thiamethoxam UDLs across each overlap scenarios for all NL48 species range are provided in **Table 3.** thiamethoxam’s action area had a mean overlap of 37%. The mean overlap out to the limits of ground and aerial drift were 71% and 84%, respectively. The mean overlaps for the individual UDLs range from 1 to 24% before incorporating usage and species life history information and <1 to 16% after incorporating for this information.

**Table 4** presents the same information for designed critical habitat. For critical habitat thiamethoxam’s action area had a mean overlap of 20%. The mean overlap out to the limits of ground and aerial drift were 39 and 49%, respectively. The mean overlaps for the individual UDLs range from <1 to 19% before incorporating usage and <1 to 17% after accounting for this information.

Table 3. Mean percent overlap and standard deviation for all NL48 species ranges and each thiamethoxam use

| **Use** | **Overlap Scenario 1: No Usage** | **Overlap Scenario 2: PCT Overlap** | **Overlap Scenario 3:****PCT and Redundancy** | **Overlap Scenario 4:****PCT, Redundancy, Off-site** |
| --- | --- | --- | --- | --- |
| Use | Mean | STD | Mean | STD | Mean | STD | Mean | STD |
| Thiamethoxam Action Area | 30 | 18 | 30 | 18 | 30 | 18 | 30 | 18 |
| Ag | 2 | 3 | 1 | 2 | 1 | 12 | <1 | 1 |
| Developed | 4 | 7 | 3 | 6 | 3 | 35 | 3 | 5 |
| Federal Lands | 10 | 14 | 10 | 14 | 10 | 14 | 10 | 14 |
| Managed Forest  | 23 | 19 | 22 | 20 | 21 | 20 | 21 | 20 |
| Field Nurseries | <1 | <1 | <1 | <1 | <1 | <1 | <1 | <1 |
| Open Space Developed | 1 | 2 | <1 | 1 | <1 | 1 | <1 | 1 |
| Poultry litter | 2 | 3 | 2 | 3 | 1 | 2 | 1 | 2 |
| Limit Ground Drift (300 m or 1000 ft) | 62 | 22 | 62 | 22 | 62 | 22 | 62 | 22 |
| Limit Aerial Drift (792m or 2600ft) | 77 | 21 | 77 | 21 | 77 | 21 | 77 | 21 |

Table 4. Mean percent overlap and standard deviation for all NL48 designated critical habitat and each thiamethoxam use

| **Use** | **Overlap Scenario 1: No Usage** | **Overlap Scenario 2: PCT Overlap** | **Overlap Scenario 3:****PCT and Redundancy** | **Overlap Scenario 4:****PCT, Redundancy, Off-site** |
| --- | --- | --- | --- | --- |
| Use | Mean | STD | Mean | STD | Mean | STD | Mean | STD |
| Thiamethoxam Action Area | 18 | 23 | 18 | 23 | 18 | 23 | 18 | 23 |
| Ag | <1 | <1 | <1 | <1 | <1 | <1 | <1 | <1 |
| Developed | <1 | 1 | <1 | 1 | <1 | 1 | <1 | 1 |
| Federal Lands | 5 | 13 | 5 | 13 | 5 | 13 | 5 | 13 |
| Managed Forest  | 18 | 23 | 18 | 23 | 18 | 23 | 18 | 23 |
| Field Nurseries | <1 | <1 | <1 | <1 | <1 | <1 | <1 | <1 |
| Open Space Developed | <1 | <1 | <1 | <1 | <1 | <1 | <1 | <1 |
| Poultry litter | <1 | <1 | <1 | <1 | <1 | <1 | <1 | <1 |
| Limit Ground Drift (300 m or 1000 ft) | 35 | 36 | 35 | 36 | 35 | 36 | 35 | 36 |
| Limit Aerial Drift (792m or 2600ft) | 44 | 43 | 44 | 43 | 44 | 43 | 44 | 43 |

## Suitable Habitat Overlap

In total 132 species were designated as species for consideration of suitable habitat 22 occur in the NL48. **Table 5** provides themean percent overlap and standard deviation for these 22 species after accounting for usage in the full range and limiting the overlap and usage extent to suitable habitat within the range. This information is considered with the results for the full species range as part of the Weight of Evidence.

Table 5. Mean percent overlap and standard deviation for uses in NL48 and suitable habitat before and after limiting the overlap extent to just suitable habitat areas. Values only include the 22 species identified for inclusion in the analysis.

| **Use** | **Overlap Scenario 4: PCT, Redundancy, Off-site** | **Overlap Scenario 5:****PCT, Redundancy, Off-site, Habitat**  |
| --- | --- | --- |
| Use | Mean | STD | Mean | STD |
| Thiamethoxam Action Area | 30 | 18 | 30 | 18 |
| Ag | <1 | 1 | <1 | 1 |
| Developed | 3 | 5 | 3 | 5 |
| Federal Lands | 10 | 14 | 10 | 14 |
| Managed Forest  | 21 | 20 | 21 | 20 |
| Field Nurseries | 0 | 0 | 0 | 0 |
| Open Space Developed | <1 | 1 | <1 | 1 |
| Poultry litter | 1 | 2 | 1 | 2 |
| Limit Ground Drift (300 m or 1000 ft) | 62 | 22 | 61 | 22 |
| Limit Aerial Drift (792m or 2600ft) | 77 | 21 | 76 | 22 |

1. Available at: <https://www.epa.gov/endangered-species/revised-method-national-level-listed-species-biological-evaluations-conventional> [↑](#footnote-ref-2)
2. Query used to extract species from TESS: <https://ecos.fws.gov/services/TessQuery?request=query&xquery=/SPECIES_DETAIL> [↑](#footnote-ref-3)
3. Statuses included: Threatened, Endangered, Experimental Population Non-Essential, Proposed Threatened, Proposed Endangered, and Candidate [↑](#footnote-ref-4)
4. <https://www.fisheries.noaa.gov/national/endangered-species-conservation/esa-threatened-endangered-species> [↑](#footnote-ref-5)
5. Website for designated critical habitat: ([http://ecos.fws.gov/crithab)](http://ecos.fws.gov/crithab) [↑](#footnote-ref-6)
6. <http://desktop.arcgis.com/en/arcmap/10.3/tools/analysis-toolbox/union.htm> [↑](#footnote-ref-7)
7. USFWS, personal communication, November 2019 [↑](#footnote-ref-8)
8. U.S. Geological Survey Gap Analysis Program, 20160513, GAP/LANDFIRE National Terrestrial Ecosystems 2011: U.S. Geological Survey: Boise, ID, <http://gapanalysis.usgs.gov/gaplandcover/.> doi:10.5066/F7ZS2TM0. [↑](#footnote-ref-9)