

# Few-Shot Learning with Localization in Realistic Settings

## (Supplementary Materials)

### 1. Additional Results

#### 1.1. Ablation Study

Top-1 and top-5 mean and per-class accuracies are given below. Three-digit model names indicate the presence or absence of batch folding, localization, and covariance pooling, in that order. For example, ‘101’ indicates a model with batch folding and covariance pooling, but no localization. Because two versions of localization exist, we use ‘0’ to indicate no localization, ‘1’ for few-shot localization, and ‘2’ for unsupervised localization. A ‘\*’ indicates a model presented in the main paper.

Model	Top-1 Accuracy		Top-5 Accuracy	
	Mean	Per-Class	Mean	Per-Class
000*	16.07 ± .19	17.55 ± .19	42.10 ± .21	41.98 ± .18
100*	20.04 ± .04	20.81 ± .08	47.86 ± .31	46.57 ± .23
010	21.55 ± .09	22.37 ± .08	50.20 ± .08	48.70 ± .08
001	24.31 ± .48	24.64 ± .39	53.29 ± .76	51.09 ± .63
020	24.32 ± .15	24.68 ± .81	53.16 ± .89	51.44 ± .94
021	25.60 ± 1.02	25.51 ± .90	54.66 ± 1.07	52.04 ± .91
110*	26.25 ± .05	26.29 ± .04	55.43 ± .09	53.01 ± .08
011	27.46 ± .15	26.39 ± .14	56.37 ± .17	52.37 ± .17
120*	28.75 ± .13	28.39 ± .15	57.90 ± .24	55.27 ± .37
101	31.06 ± .61	29.07 ± .53	60.41 ± .67	55.50 ± .62
121*	32.74 ± .13	30.52 ± .13	61.32 ± .14	56.62 ± .16
111*	35.52 ± .05	31.69 ± .06	63.76 ± .09	57.33 ± .10

Between any two models with different numbers of features, the one with more always outperforms the one with less, regardless of combination. Thus batch folding, localization, and covariance pooling consistently and independently improve performance on meta-iNat.

#### 1.2. Learning Without Forgetting

We evaluate the ability of our prototype-styled classifiers to adapt to new concepts without forgetting old ones. We combine the evaluation and representation sets of meta-iNat into a single, larger dataset and provide accuracy numbers for prototype-styled classifiers. Softmax classifiers are ignored, as they cannot handle old and new concepts simultaneously without completely replacing the topmost fully-connected layer. While accuracy decreases overall (we are now distinguishing between 1135 categories rather than 227), batch folding, few-shot localization, and covariance pooling still lead to significant improvements. For logistical reasons, we run only one trial in all settings, though we still evaluate four independently trained models for each.

Model	Top-1 Accuracy		Top-5 Accuracy	
	Mean	Per-Class	Mean	Per-Class
Baseline	6.64 ± .06	7.37 ± .08	21.08 ± .13	21.08 ± .19
Batch Folding	8.87 ± .13	9.35 ± .14	25.92 ± .20	25.13 ± .16
BF + few-shot localization	13.22 ± .04	13.11 ± .07	33.54 ± .12	31.60 ± .12
BF + fsL + covariance pooling	20.69 ± .16	17.44 ± .13	43.70 ± .23	37.17 ± .33

### 2. Network Architectures

Our learner architectures mimic the original prototypical networks. Networks contain four 64-channel  $3 \times 3$  convolutional layers, with Batchnorm, ReLU, and  $2 \times 2$  max-pooling in between. This is followed by Batchnorm and  $10 \times 10$  global average-pooling, for a 64-dimensional feature vector. Unlike prototypical networks, which flatten the feature map to a

6400-dimensional vector, we use average pooling to eliminate spatial priors on uncentered, uncropped images. Softmax classifier models use a fully-connected layer on top of the feature vector; prototype classifiers use the feature vector directly. Localization and covariance pooling models replace average-pooling layers with the appropriate algorithm(s).

Models based on ResNet50 use the first two stages of a ResNet50 model, pretrained on ImageNet, to produce  $28 \times 28$  feature maps with 512 channels. Learned layers consist of  $2 \times 2$  max-pooling, followed by  $3 \times 3$  convolution with 128 channels, Batchnorm, ReLU, a second  $3 \times 3$  convolution with 64 channels, and Batchnorm. The resulting  $14 \times 14$  feature maps are localized, average pooled, or covariance pooled as appropriate. As in the original setting, softmax classifiers use an additional fully-connected layer, while prototype architectures use the pooled embeddings directly.

### 3. Training and Implementation Details

#### 3.1. Training

We train meta-iNat models via SGD with Adam, using an initial learning rate of  $10^{-3}$  and dividing by two every epoch. Each epoch consists of 10 passes over the representation set, with five epochs in total. For mini-ImageNet, we lengthen each epoch to 28 passes, to account for the smaller representation set.

In both settings we unit-normalize input color channels. We use random horizontal flipping but no other data augmentation. Because bounding boxes are downsized to very small resolutions (e.g.  $10 \times 10$ ), we use  $4 \times 4$  average-pooling before downsampling, as a fast approximation for anti-aliasing.

#### 3.2. Batch Sampling

While mini-ImageNet uses random batch sampling with replacement during training and testing, meta-iNat uses a different sampling procedure for each. During each training iteration, classes are sampled without replacement: so long as classes have sufficient remaining images to create a batch, they are sampled proportionately to the number of available images they contain. This ensures that differently-sized classes occur at constant, representative rates throughout the entire sampling process. Images are then selected from the sampled classes, and those images are subsequently unavailable for further training until the next pass over the dataset.

During testing, we wish to evaluate classification accuracy for relatively large numbers of classes and images. For sufficiently high values, it becomes impossible to process the sampled datasets as single batches in computer memory. Category sizes also vary so widely that it no longer makes sense to use constant sample sizes. Rather than attempt to evaluate a given network on a large number of large and complicated datasets, we instead impose a single reference/query split over the evaluation set.

Evaluation consists of one pass over the reference images followed by one pass over the query images. During the reference pass, each category is split into manageable batches, and the class centroid is computed from a running total of the embedding vectors. The query pass is divided the same way, and the pre-computed centroids are used to make class predictions. When localization is used, we run 10 trials where different 10% subsets of the reference images are randomly selected to receive bounding box annotations.

The above applies to prototype-styled classifiers, which require representation and query sets for a limited selection of classes in every batch. For straightforward softmax classifiers, we instead use random sampling without replacement, and a batch size of 128. Annealing schedule is as above.

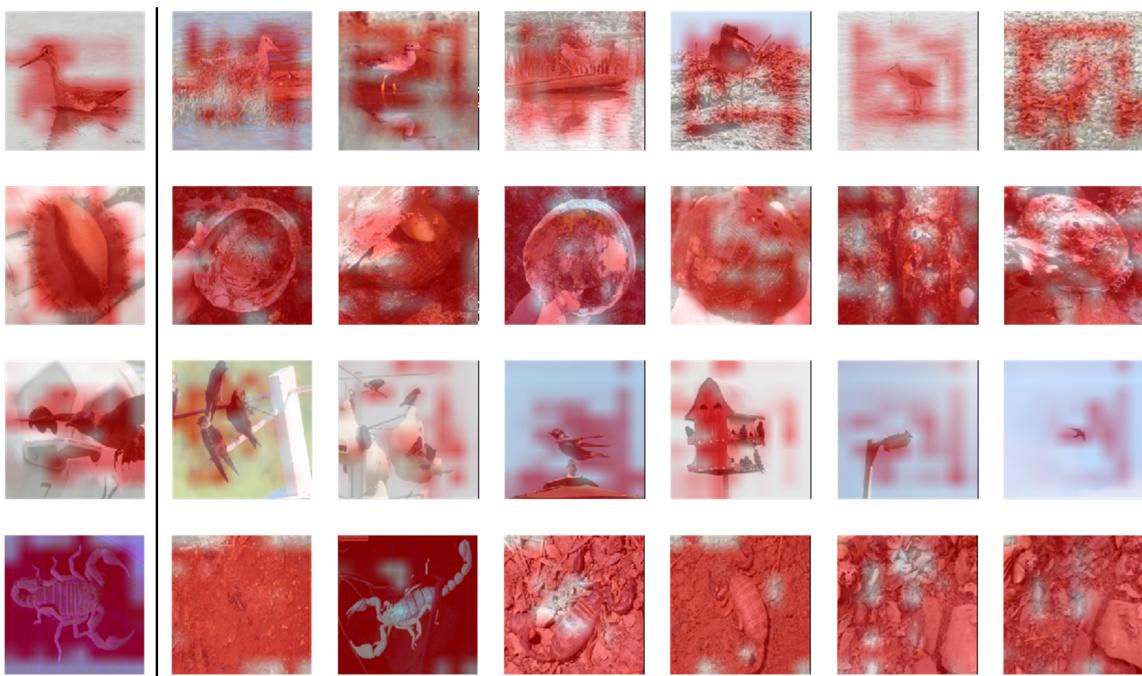
## 4. Additional Few-Shot Localization Examples

When individual bounding boxes in the annotated reference image are small, localization tends to work well, given the model's lack of power (a four-layer network with  $10 \times 10$  outputs and no localization supervision). The leftmost image provides the ground truth bounding box(es).

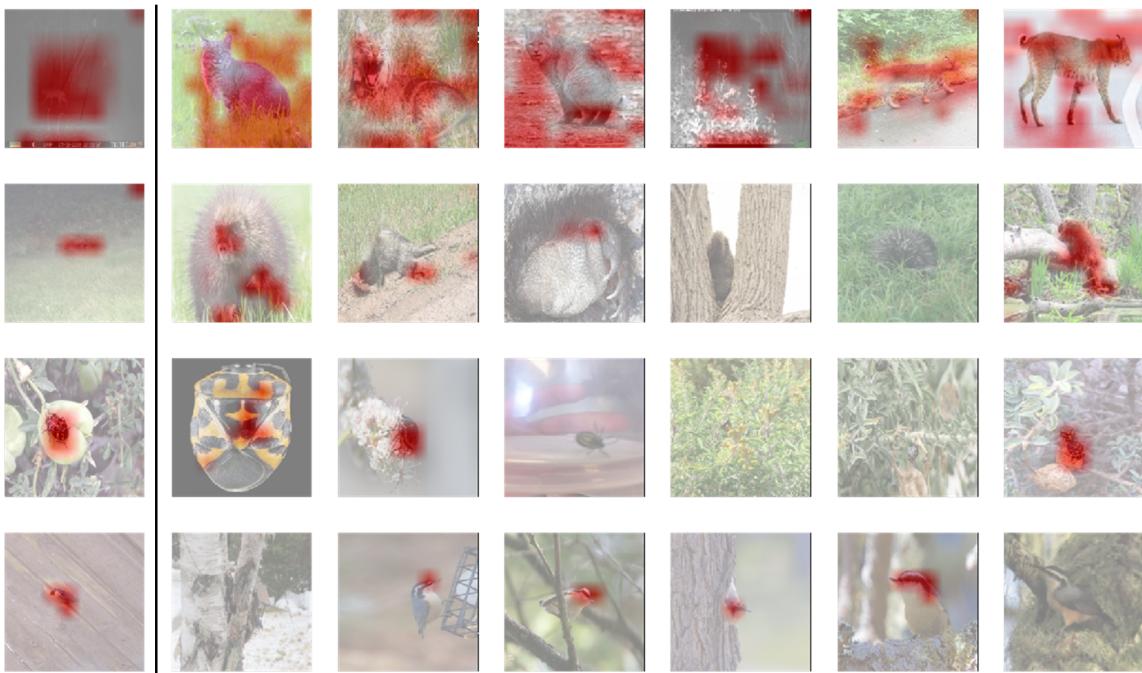


#### 4.1. Failure cases

When bounding boxes in the annotated reference image are too large or too small, localizer performance breaks down. In the former case, too much of the background is included in the bounding box, and the localizer becomes over-inclusive.



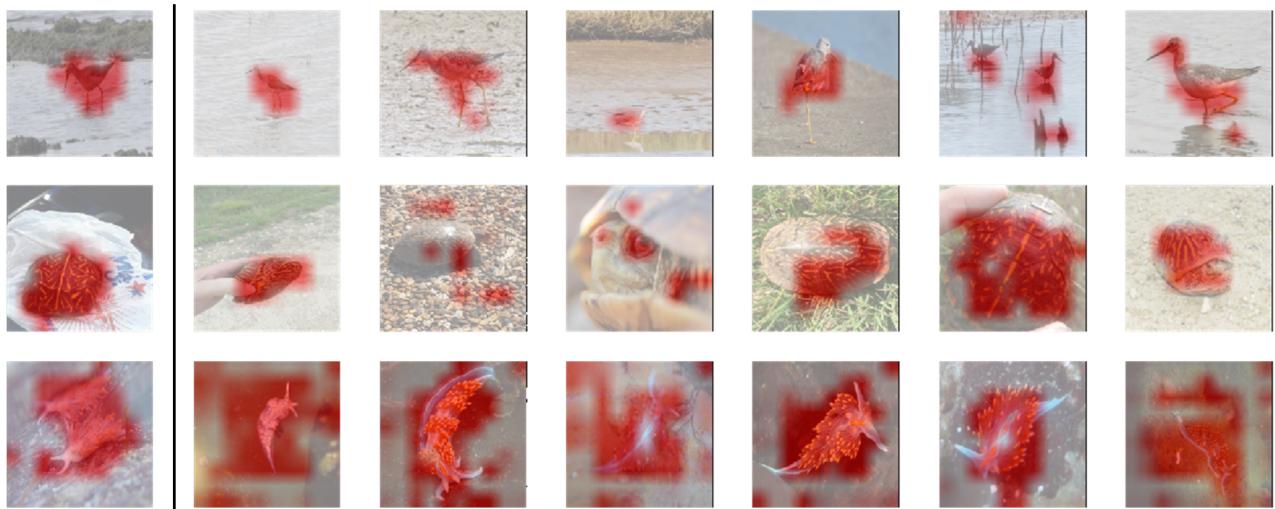
When bounding boxes are too small, the localizer focuses on the wrong things, selects small parts of the object in question, or in some cases fails to detect a region of interest at all.



## 4.2. Additional annotations

Localizer performance generally improves as more annotations are made available.

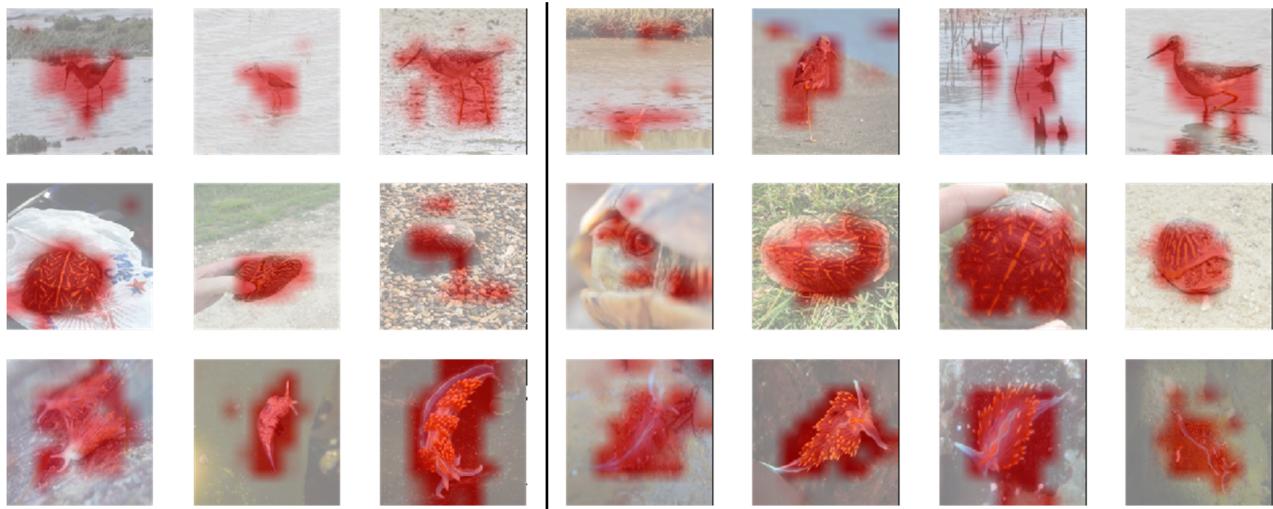
**One annotation per row:** The localizer often selects only parts of the relevant object, or includes significant portions of the background.



**Two annotations per row:** The localizer has eliminated much of the irrelevant background areas from its predictions, increasing precision (see bottom row in particular), as well as including more of the relevant object.



**Three annotations per row:** The localizer includes larger portions for photos where it originally selected only a small subregion, improving recall (see middle row in particular).



## 5. Meta-iNat Category Splits

The code for meta-iNat is available on GitHub, but we list the category assignments here for the sake of completeness.

### Evaluation Categories

Arachnida/Nephila clavipes	Aves/Cygnus columbianus	Aves/Sialia currucoides
Aves/Cyanocitta cristata	Animalia/Patiriella regularis	Aves/Sphyrapicus varius
Insecta/Phoebis sennae	Insecta/Hypsopygia olinalis	Aves/Zosterops lateralis
Aves/Selasphorus sasin	Insecta/Ischnura elegans	Insecta/Lasiommata megera
Aves/Anas platyrhynchos domesticus	Aves/Todiramphus sanctus vagans	Insecta/Anthanassa tulcis
Mollusca/Hermisenda opalescens	Aves/Melanerpes carolinus	Insecta/Stagmomantis carolina
Insecta/Murgantia histrionica	Insecta/Atalopedes campestris	Insecta/Tramea onusta
Aves/Clangula hyemalis	Aves/Aphelocoma californica	Insecta/Sceliphron caementarium
Insecta/Speranza pustularia	Aves/Sitta canadensis	Aves/Corvus monedula
Aves/Buteo regalis	Mollusca/Ariolimax columbianus	Insecta/Papilio rutulus
Aves/Gerygone igata	Insecta/Pantala flavescens	Insecta/Argia apicalis
Insecta/Aeshna umbrosa	Insecta/Polistes exclamans	Aves/Polioptila caerulea
Insecta/Nomophila nearctica	Aves/Geranoaetus albicaudatus	Amphibia/Anaxyrus fowleri
Reptilia/Sauromalus ater	Arachnida/Phidippus johnsoni	Aves/Petroica australis longipes
Aves/Athene cunicularia	Aves/Numenius phaeopus	Reptilia/Crotalus oreganus oreganus
Aves/Vireo olivaceus	Aves/Rynchops niger	Reptilia/Pituophis catenifer annectens
Aves/Chloroceryle americana	Aves/Tadorna variegata	Mammalia/Sylvilagus audubonii
Insecta/Scopula limboundata	Aves/Tigrisoma mexicanum	Aves/Baeolophus bicolor
Insecta/Clepsis peritana	Aves/Gallus gallus domesticus	Aves/Oreothlypis peregrina
Insecta/Xylocopa virginica	Aves/Phalaropus lobatus	Mammalia/Orcinus orca
Insecta/Leucorrhinia intacta	Insecta/Sympetrum pallipes	Reptilia/Nerodia erythrogaster transversa
Reptilia/Ctenosaura similis	Reptilia/Aspidoscelis gularis	Aves/Chen caerulescens
Insecta/Speyeria cybele	Aves/Botaurus lentiginosus	Mammalia/Tamias striatus
Reptilia/Uta stansburiana elegans	Aves/Thalasseus elegans	Aves/Progne subis
Mammalia/Odocoileus hemionus californicus	Animalia/Strongylocentrotus purpuratus	Aves/Charadrius nivosus
Insecta/Polistes carolina	Aves/Contopus sordidulus	Mammalia/Lynx rufus
Reptilia/Diadophis punctatus	Amphibia/Lithobates berlandieri	Aves/Amazilia violiceps
Insecta/Maniola jurtina	Amphibia/Eurycea bislineata	Aves/Corvus corax
Aves/Melanerpes chrysogenys	Aves/Podiceps auritus	Aves/Pica hudsonia
Aves/Egretta rufescens	Insecta/Tramea lacerata	Aves/Platalea ajaja
Insecta/Callophrys gryneus	Reptilia/Terrapene ornata	Aves/Passerina cyanea
Mollusca/Haliotis rufescens	Aves/Spinus pinus	Insecta/Argia immunda
Reptilia/Coluber constrictor	Aves/Spizelloides arborea	Aves/Histrionicus histrionicus
Insecta/Cycloneda sanguinea	Insecta/Idia americalis	Aves/Melozone crissalis
Insecta/Anax junius	Insecta/Plutella xylostella	Reptilia/Hierophis viridiflavus
Mollusca/Acanthodoris lutea	Mammalia/Sylvilagus floridanus	Aves/Poecile carolinensis
Aves/Momotus mexicanus	Insecta/Papilio multicaudata	Mollusca/Octopus rubescens
Reptilia/Pituophis catenifer sayi	Insecta/Asterocampa clyton	Aves/Cassiculus melanicterus
Amphibia/Plethodon albagula	Reptilia/Phrynosoma hernandesi	Aves/Sterna forsteri
Reptilia/Thamnophis proximus	Insecta/Macromia illinoiensis	Aves/Auriparus flaviceps
Mammalia/Erethizon dorsatum	Amphibia/Lithobates palustris	Aves/Phalacrocorax varius varius
Arachnida/Phidippus audax	Insecta/Chauliognathus pensylvanicus	Insecta/Toxomerus marginatus
Reptilia/Thamnophis proximus orarius	Mollusca/Mopalia muscosa	Insecta/Promachus hinei
Aves/Falco mexicanus	Mollusca/Lottia gigantea	Aves/Toxostoma redivivum
Aves/Pipilo erythrorththalmus	Insecta/Ceratomia undulosa	Reptilia/Heterodon platirhinos
Insecta/Eacles imperialis	Arachnida/Salticus scenicus	Aves/Larus glaucescens

Aves/Alopochen aegyptiaca	Aves/Larus occidentalis
Reptilia/Plestiodon fasciatus	Aves/Prunella modularis
Insecta/Papilio eurymedon	Reptilia/Phrynosoma blainvillii
Insecta/Lygaeus kalmii	Aves/Aramus guarauna
Aves/Calidris melanotos	Insecta/Hypoprepia fucosa
Aves/Molothrus ater	Insecta/Erynnis tristis
Aves/Pelecanus occidentalis californicus	Amphibia/Taricha rivularis
Insecta/Dryas iulia	Aves/Aythya fuligula
Reptilia/Pantherophis obsoletus lindheimeri	Animalia/Pollicipes polymerus
Insecta/Dryocampa rubicunda	Insecta/Cercyonis pegala
Animalia/Armadillidium vulgare	Aves/Pica pica
Mammalia/Lontra canadensis	Aves/Larus heermanni
Reptilia/Agkistrodon piscivorus leucostoma	Aves/Phainopepla nitens
Insecta/Epitheca princeps	Animalia/Pachygrapsus crassipes
Aves/Lanius collurio	Mammalia/Castor canadensis
Aves/Campylorhynchus brunneicapillus	Amphibia/Salamandra salamandra
Insecta/Polygonia interrogationis	Insecta/Anartia jatrophae
Insecta/Chiooides albofasciatus	Insecta/Aedes albopictus
Reptilia/Crotalus horridus	Mammalia/Bison bison
Aves/Vireo griseus	Reptilia/Lampropeltis californiae
Insecta/Danaus gilippus	Insecta/Gomphus militaris
Insecta/Ladona deplanata	Aves/Chlidonias niger
Aves/Junco phaeonotus	Animalia/Physalia physalis
Aves/Chroicocephalus ridibundus	Aves/Eolophus roseicapilla
Insecta/Archilestes grandis	Aves/Phalacrocorax penicillatus
Arachnida/Uroctonus mordax	Reptilia/Chrysemys picta marginata
Actinopterygii/Lepomis macrochirus	Insecta/Epargyreus clarus
Insecta/Libellula forensis	Insecta/Bombus impatiens
Aves/Calidris alba	Aves/Protonotaria citrea
Aves/Ictinia mississippiensis	Insecta/Pyrgus communis
Mammalia/Ursus americanus	Insecta/Bombus ternarius
Insecta/Glaucopsyche lygdamus	Insecta/Anax longipes
Aves/Lonchura punctulata	Aves/Cyanistes caeruleus
Arachnida/Neoscona oaxacensis	Insecta/Polites peckius
Aves/Loxia curvirostra	Insecta/Orthemis ferruginea
Insecta/Polyphylla decemlineata	Insecta/Actias luna
Aves/Aegithalos caudatus	Actinopterygii/Salvelinus fontinalis
Reptilia/Crotalus molossus	Reptilia/Thamnophis elegans
Amphibia/Anaxyrus woodhousii	Insecta/Colias philodice
Aves/Vireo gilvus	
Aves/Sialia sialis	
Aves/Amphispiza bilineata	
Aves/Egretta novaehollandiae	
Insecta/Anicla infecta	
Aves/Tringa melanoleuca	
Amphibia/Lithobates sylvaticus	
Aves/Himantopus mexicanus	
Insecta/Chlosyne nycteis	
Aves/Anser anser domesticus	

## Representation Categories

Reptilia/Sceloporus poinsetti	Reptilia/Gopherus agassizii	Insecta/Dythemis fugax
Aves/Chordeiles minor	Insecta/Hemaris thysbe	Insecta/Zelus longipes
Aves/Anas cyanoptera	Mammalia/Thomomys bottae	Insecta/Ascalapha odorata
Reptilia/Opheodrys aestivus	Aves/Zonotrichia atricapilla	Aves/Icterus cucullatus
Aves/Pelecanus erythrorhynchos	Insecta/Spoladea recurvalis	Insecta/Heliopetes ericetorum
Aves/Tyrannus tyrannus	Mammalia/Nasua narica	Aves/Eremophila alpestris
Reptilia/Ctenosaura pectinata	Amphibia/Hyla cinerea	Insecta/Darapsa myron
Insecta/Lophocampa maculata	Aves/Ardea cinerea	Insecta/Nymphalis californica
Mollusca/Aeolidia papillosa	Aves/Gallinago delicata	Reptilia/Rhinocheilus lecontei
Mammalia/Mus musculus	Insecta/Strymon melinus	Aves/Branta hutchinsii
Arachnida/Centruroides vittatus	Aves/Elanus leucurus	Aves/Columba palumbus
Reptilia/Nerodia sipedon	Aves/Euphagus carolinus	Aves/Coccyzus americanus
Amphibia/Batrachoseps attenuatus	Insecta/Pyrgus oileus	Aves/Picoides villosus
Insecta/Celithemis eponina	Mammalia/Antilocapra americana	Aves/Rallus limicola
Mammalia/Tursiops truncatus	Aves/Turdus pilaris	Mollusca/Corbicula fluminea
Insecta/Heraclides cresphontes	Insecta/Cupido comyntas	Aves/Stelgidopteryx serripennis
Aves/Phasianus colchicus	Insecta/Euphyes vestris	Aves/Geopelia striata
Insecta/Asterocampa celtis	Insecta/Hymenia perspectalis	Aves/Thryothorus ludovicianus
Aves/Setophaga discolor	Animalia/Anthopleura sola	Mammalia/Sciurus vulgaris
Aves/Motacilla cinerea	Insecta/Mantis religiosa	Aves/Limosa fedoa
Reptilia/Sceloporus orcutti	Insecta/Automeris io	Reptilia/Basiliscus vittatus
Aves/Tachybaptus ruficollis	Insecta/Libellula cyanea	Aves/Porphyrio melanotus melanotus
Aves/Streptopelia decaocto	Insecta/Megacyllene robiniae	Insecta/Sympetrum vicinum
Insecta/Chinavia hilaris	Mammalia/Cervus elaphus	Insecta/Argia moesta
Aves/Anser cygnoides domesticus	Reptilia/Coluber constrictor flaviventris	Reptilia/Dipsosaurus dorsalis
Aves/Cistothorus palustris	Insecta/Pararge aegeria	Amphibia/Ambystoma opacum
Reptilia/Lampropeltis holbrookii	Aves/Larus hyperboreus	Insecta/Malacosoma disstria
Aves/Garrulus glandarius	Insecta/Argia translata	Aves/Acanthis flammea
Reptilia/Actinemys marmorata	Aves/Archilochus alexandri	Insecta/Heraclides rumiko
Insecta/Forficula auricularia	Arachnida/Aphonopelma hentzi	Aves/Junco hyemalis oreganus
Mammalia/Sciurus griseus	Insecta/Spilosoma virginica	Arachnida/Araneus diadematus
Aves/Colaptes auratus	Aves/Microcarbo melanoleucus brevirostris	Aves/Catharus guttatus
Aves/Melanerpes aurifrons	Aves/Porzana carolina	Aves/Tyrannus melancholicus
Aves/Carduelis carduelis	Insecta/Necrophila americana	Amphibia/Anaxyrus punctatus
Aves/Gymnogyps californianus	Aves/Sitta carolinensis	Amphibia/Pseudacris hypochondriaca
Aves/Bucephala clangula	Mammalia/Tamiasciurus hudsonicus	Insecta/Battus philenor
Aves/Passerina amoena	Aves/Picoides scalaris	Insecta/Sphecius speciosus
Insecta/Papilio polyxenes asterius	Aves/Icterus gularis	Insecta/Micrathyria hagenii
Aves/Ammodramus savannarum	Insecta/Calycopis isobeon	Insecta/Malacosoma americanum
Aves/Butorides striata	Aves/Setophaga fusca	Insecta/Hetaerina titia
Amphibia/Pseudacris cadaverina	Mollusca/Limax maximus	Aves/Passerina versicolor
Insecta/Erpetogomphus designatus	Aves/Cardinalis sinuatus	Aves/Anas acuta
Aves/Vanellus vanellus	Aves/Galerida cristata	Reptilia/Aspidoscelis tigris stejnegeri
Insecta/Romalea microptera	Reptilia/Hemidactylus frenatus	Aves/Ornithodoros vetula
Aves/Baeolophus inornatus	Insecta/Cotinis mutabilis	Reptilia/Iguana iguana
Aves/Campylophilus guatemalensis	Aves/Haematopus bachmani	Mammalia/Marmota flaviventris
Animalia/Patiria miniata	Insecta/Costaconvexa centrostrigaria	Aves/Callipepla californica
Reptilia/Crotalus oreganus helleri	Insecta/Polistes apachus	Aves/Cyanocorax yncas
Insecta/Ischnura cervula	Aves/Piaya cayana	Mammalia/Oryctolagus cuniculus
Insecta/Aglais milberti		Reptilia/Chrysemys picta picta
Aves/Aix sponsa		

Aves/Larus michahellis		Aves/Nestor meridionalis septentrionalis	Amphibia/Gastrophryne carolinensis
Aves/Aythya collaris		Aves/Parkesia noveboracensis	Insecta/Limenitis arthemis
Reptilia/Agkistrodon contortrix		Reptilia/Storeria dekayi	Mammalia/Procyon lotor
Aves/Poecile rufescens		Aves/Thraupis abbas	Reptilia/Arizona elegans
Aves/Arenaria interpres		Insecta/Polyommatus icarus	Arachnida/Argiope aurantia
Insecta/Lophocampa caryae		Aves/Parabuteo unicinctus	Amphibia/Lithobates pipiens
Aves/Thalasseus sandvicensis		Animalia/Limulus polyphemus	Insecta/Labidomera clivicollis
Aves/Geococcyx californianus		Aves/Turdus philomelos	Insecta/Oncopeltus fasciatus
Insecta/Adelpha californica		Aves/Dryocopus lineatus	Aves/Thalasseus maximus
Aves/Buteo lagopus		Arachnida/Dysdera crocata	Insecta/Diabrotica undecimpunctata
Insecta/Papilio polyxenes		Insecta/Xanthocnemis zealandica	Aves/Corvus corone
Aves/Pooecetes gramineus		Aves/Anas superciliosa platyrhynchos	Amphibia/Taricha granulosa
Aves/Setophaga nigrescens		Aves/Dryocopus pileatus	Aves/Melospiza lincolni
Aves/Pipilo maculatus		Insecta/Enallagma basidens	Insecta/Noctua pronuba
Aves/Pluvialis fulva		Aves/Charadrius semipalmatus	Amphibia/Lithobates sphenocephalus
Insecta/Libellula croceipennis		Aves/Accipiter striatus	Reptilia/Sonora semiannulata
Arachnida/Leucauge venusta		Mammalia/Alces americanus	Insecta/Libellula comanche
Insecta/Urola nivalis		Insecta/Hypercompe scribonia	Insecta/Calycoptis cecrops
Amphibia/Rhinella marina		Insecta/Anthanassa texana	Mammalia/Capreolus capreolus
Reptilia/Coleonyx brevis		Amphibia/Pseudacris regilla	Insecta/Chrysochus auratus
Arachnida/Paraphidippus aurantius		Insecta/Mythimna unipuncta	Insecta/Ctenucha virginica
Aves/Molothrus aeneus		Aves/Podilymbus podiceps	Aves/Oenanthe oenanthe
Aves/Regulus satrapa		Reptilia/Gopherus polyphemus	Insecta/Lethe anthedon
Aves/Egretta tricolor		Insecta/Brachymesia gravida	Amphibia/Scaphiopus couchii
Insecta/Udea rubigalis		Mammalia/Zalophus californianus	Aves/Caracara cheriway
Insecta/Nymphalis antiopa		Aves/Buteo plagiatus	Aves/Quiscalus quiscula
Insecta/Homalodisca vitripennis		Aves/Pheucticus melanocephalus	Aves/Picoides nuttallii
Aves/Columbina talpacoti		Aves/Actitis macularius	Aves/Setophaga virens
Aves/Chondestes grammacus		Aves/Spizella pusilla	Mammalia/Odocoileus hemionus
Insecta/Vanessa itea		Insecta/Euphydryas chalcedona	Insecta/Poanes zabulon
Insecta/Papilio zelicaon		Aves/Troglodytes aedon	Insecta/Sphex ichneumoneus
Mollusca/Mytilus californianus		Mammalia/Didelphis virginiana	Mammalia/Tamiasciurus douglasii
Aves/Vireo huttoni		Insecta/Sympetrum semicinctum	Aves/Lanius ludovicianus
Aves/Hydroprogne caspia		Aves/Nucifraga columbiana	Insecta/Sympetrum obtrusum
Aves/Vireo solitarius		Arachnida/Argiope argentata	Aves/Selasphorus platycercus
Insecta/Ischnura denticollis		Aves/Tringa incana	Aves/Actitis hypoleucus
Aves/Haemorhous purpureus		Aves/Icterus spurius	Arachnida/Latrodectus hesperus
Insecta/Aglais urticae		Aves/Tyrannus verticalis	Animalia/Pisaster ochraceus
Amphibia/Notophthalmus descens	viri-	Aves/Tringa solitaria	Aves/Gallinula galeata
Aves/Zenaida asiatica		Aves/Aquila chrysaetos	Aves/Cyanocitta stelleri
Reptilia/Pantherophis emoryi		Reptilia/Virginia striatula	Insecta/Lestes australis
Insecta/Nathalis iole		Mollusca/Doriopsilla albopunctata	Mammalia/Lepus europaeus
Aves/Toxostoma curvirostre		Insecta/Dromogomphus spoliatus	Reptilia/Sceloporus variabilis
Animalia/Velella velella		Insecta/Rhionaeschna multicolor	Reptilia/Natrix natrix
Insecta/Melissodes bimaculata		Aves/Volatinia jacarina	Insecta/Argia sedula
Mammalia/Phoca vitulina		Amphibia/Incilius nebulifer	Insecta/Coleomegilla maculata
Mollusca/Antaeolidiella oliviae		Aves/Melanerpes uropygialis	Aves/Tringa flavipes
Aves/Contopus virens		Aves/Tyrannus vociferans	Aves/Charadrius melanotos
Reptilia/Phrynosoma cornutum		Insecta/Megisto cymela	Insecta/Limenitis archippus
Mammalia/Marmota monax		Aves/Limnodromus griseus	Mollusca/Cryptochiton stelleri
Reptilia/Heloderma suspectum		Insecta/Zelus renardii	Aves/Buteo platypterus
Insecta/Phoebis agarithe		Aves/Fringilla coelebs	Insecta/Dolichovespula maculata

Aves/Plegadis chihi	Insecta/Largus californicus	Aves/Perisoreus canadensis
Aves/Bonasa umbellus	Insecta/Urbanus proteus	Aves/Mniotilla varia
Aves/Tringa semipalmata	Reptilia/Aspidoscelis sexlineata	Aves/Leucophaeus pipixcan
Aves/Spiza americana	Aves/Calidris mauri	Aves/Pyrocephalus rubinus
Aves/Periparus ater	Aves/Aythya americana	Insecta/Cotinis nitida
Aves/Egretta caerulea	Amphibia/Ambystoma maculatum	Aves/Recurvirostra americana
Aves/Oxyura jamaicensis	Aves/Contopus cooperi	Aves/Selasphorus rufus
Insecta/Hippodamia convergens	Aves/Certhia americana	Insecta/Euchaetes egle
Insecta/Atteva aurea	Aves/Mycteria americana	Aves/Ardenna creatopus
Aves/Cygnus olor	Amphibia/Anaxyrus boreas	Aves/Tachycineta bicolor
Insecta/Dromogomphus spinosus	halophilus	Insecta/Eumorpha pandorus
Reptilia/Chrysemys picta	Insecta/Phyciodes mylitta	Arachnida/Peucetia viridans
Aves/Ciconia ciconia	Insecta/Euphydryas phaeton	Aves/Setophaga coronata auduboni
Insecta/Urbanus procne	Insecta/Caenurgina erechtea	Aves/Passerina ciris
Mollusca/Rumina decollata	Insecta/Echinargus isola	Aves/Poecile atricapillus
Reptilia/Sphenodon punctatus	Aves/Hylocichla mustelina	Mammalia/Phocarctos hookeri
Insecta/Lymantria dispar	Arachnida/Latrodectus mactans	Aves/Cygnus atratus
Aves/Columbina inca	Insecta/Epiaschna heros	Reptilia/Tarentola mauritanica
Aves/Rhipidura leucophrys	Aves/Passerina caerulea	Aves/Catharus ustulatus
Mollusca/Okenia rosacea	Insecta/Argia fumipennis	Animalia/Cancer productus
Animalia/Callinectes sapidus	Animalia/Pugettia producta	Aves/Pitangus sulphuratus
Aves/Gallinula chloropus	Mammalia/Mirounga angustirostris	Insecta/Argia plana
Insecta/Celithemis elisa	Amphibia/Hyla chrysoscelis	Insecta/Ischnura hastata
Reptilia/Scincella lateralis	Insecta/Ochlodes sylvanoides	Insecta/Plebejus acmon
Insecta/Pieris napi	Reptilia/Pituophis catenifer catenifer	Aves/Glaucidium brasiliandum
Aves/Bucephala islandica	Insecta/Hypena scabra	Mammalia/Pecari tajacu
Aves/Falco tinnunculus	Amphibia/Bufo bufo	Reptilia/Chelydra serpentina
Amphibia/Anaxyrus boreas	Aves/Pipilo chlorurus	Aves/Sula nebouxii
Insecta/Bagrada hilaris	Insecta/Cicindela repanda	Aves/Pelecanus occidentalis
Amphibia/Plethodon cinereus	Aves/Columba livia domestica	Aves/Turdus grayi
Aves/Prosthemadera novaeseelandiae	Insecta/Aglais io	Mollusca/Tegula funebralis
Insecta/Sympetrum illotum	Reptilia/Plestiodon skiltonianus	Aves/Cynanthus latirostris
Reptilia/Terrapene carolina triunguis	Insecta/Anaea andria	Insecta/Thymelicus lineola
Aves/Jacana spinosa	Mammalia/Megaptera novaeangliae	Aves/Sporophila torqueola
Insecta/Coenonympha tullia californica	Reptilia/Anguis fragilis	Aves/Tyrannus forficatus
Mammalia/Neovison vison	Aves/Aythya marila	Insecta/Polygonia comma
Mollusca/Triopha catalinae	Insecta/Vanessa virgininiensis	Insecta/Melanoplus bivittatus
Aves/Plegadis falcinellus	Amphibia/Hyla versicolor	Mollusca/Hermisenda crassicornis
Aves/Anas strepera	Mammalia/Oreamnos americanus	Aves/Branta bernicla
Aves/Bubulcus ibis	Reptilia/Crotalus viridis	Aves/Thraupis episcopus
Mammalia/Enhydra lutris nereis	Insecta/Enallagma exsulans	Insecta/Mestra amymone
Insecta/Ascia monuste	Insecta/Sympetrum corruptum	Insecta/Telebasis salva
Aves/Haematopus palliatus	Mollusca/Diaulula sandiegensis	Aves/Calidris minutilla
Aves/Calidris virgata	Insecta/Macroglossum stellatarum	Insecta/Vespa crabro
Insecta/Pelidnota punctata	Aves/Piranga rubra	Amphibia/Dicamptodon ensatus
Aves/Nestor meridionalis	Reptilia/Alligator mississippiensis	Insecta/Ladona julia
Amphibia/Smilisca baudinii	Aves/Dumetella carolinensis	Mollusca/Cepaea nemoralis
Aves/Mergus merganser	Amphibia/Anaxyrus speciosus	Insecta/Atlides halesus
Aves/Bubo scandiacus	Amphibia/Pelophylax	Aves/Setophaga petechia
Reptilia/Tantilla gracilis	Insecta/Coenonympha tullia	Mammalia/Erinaceus europaeus
Aves/Euphagus cyanocephalus	Insecta/Erynnis horatius	Reptilia/Coluber lateralis lateralis
Insecta/Papilio troilus	Aves/Setophaga caerulescens	Animalia/Dermasterias imbricata
	Amphibia/Pseudacris sierra	Insecta/Libytheana carinenta

Insecta/Pantala hymenaea	Aves/Acridotheres tristis	Aves/Arenaria melanocephala
Aves/Icterus bullockii	Aves/Porphyrio martinicus	Amphibia/Ensatina eschscholtzii xanthoptica
Aves/Falco columbarius	Animalia/Epiactis prolifera	Arachnida/Misumena vatia
Aves/Aythya valisineria	Aves/Leucophaeus atricilla	Insecta/Bombus terrestris
Aves/Calidris pusilla	Aves/Streptopelia chinensis	Aves/Piranga olivacea
Insecta/Vanessa annabella	Aves/Anas discors	Reptilia/Pantherophis alleghaniensis
Mollusca/Tonicella lineata	Mammalia/Ochotona princeps	Aves/Phalaropus tricolor
Aves/Crotophaga sulcirostris	Aves/Mergus serrator	Insecta/Campaea perlata
Reptilia/Sceloporus undulatus	Insecta/Enallagma civile	Insecta/Prochoerodes lineola
Aves/Anas crecca	Aves/Upupa epops	Aves/Myiarchus cinerascens
Aves/Rostrhamus sociabilis	Mammalia/Panthera leo	Aves/Baeolophus atricristatus
Aves/Chloris chloris	Aves/Fulmarus glacialis	Animalia/Anthopleura xanthogrammica
Insecta/Abaeis nicippe	Arachnida/Neoscona crucifera	Aves/Chen rossii
Aves/Anser anser	Insecta/Coccinella septempunctata	Aves/Antigone canadensis
Aves/Larus dominicanus dominicanus	Mammalia/Otospermophilus variegatus	Aves/Parus major
Insecta/Spodoptera ornithogalli	Reptilia/Coluber flagellum testaceus	Amphibia/Rana temporaria
Reptilia/Podarcis sicula	Amphibia/Notophthalmus viridescens	Mammalia/Equus quagga
Insecta/Haploa clymene	Aves/Psilorhinus morio	Insecta/Hetaerina americana
Insecta/Jadera haematoloma	Insecta/Libellula vibrans	Mollusca/Deroceras reticulatum
Aves/Sturnella magna	Aves/Passer montanus	Insecta/Chlosyne lacinia
Aves/Milvus migrans	Aves/Bubo virginianus	Insecta/Phyciodes tharos
Aves/Alcedo atthis	Aves/Dolichonyx oryzivorus	Reptilia/Nerodia rhombifer
Insecta/Hyles lineata	Aves/Passerella iliaca	Mammalia/Urocyon cinereoargenteus
Aves/Zonotrichia albicollis	Aves/Icterus abeillei	Reptilia/Phrynosoma modestum
Reptilia/Crotalus scutulatus	Aves/Strix varia	Aves/Buteo swainsoni
Aves/Ptiliogonyx cinereus	Aves/Patagioenas flavirostris	Insecta/Tetraopes tetrophthalmus
Mammalia/Felis catus	Aves/Setophaga citrina	Aves/Phoenicurus ochruros
Insecta/Ancyloxypha numitor	Aves/Emberiza citrinella	Reptilia/Crotalus oreganus
Arachnida/Gasteracantha formis	Reptilia/Thamnophis sirtalis sirtalis	Insecta/Pontia protodice
Insecta/Papilio canadensis	Aves/Sialia mexicana	Insecta/Eurytides marcellus
Insecta/Xylophanes tersa	Animalia/Procambarus clarkii	Insecta/Ischnura posita
Aves/Petrochelidon pyrrhonota	Reptilia/Hemidactylus turcicus	Insecta/Pseudoleon superbus
Insecta/Bombus griseocollis	Aves/Larus californicus	Aves/Erithacus rubecula
Aves/Anser albifrons	Aves/Cairina moschata domestica	Animalia/Emerita analoga
Aves/Gavia immer	Aves/Tityra semifasciata	Insecta/Tenodera sinensis
Insecta/Limenitis arthemis astyanax	Reptilia/Crotaphytus collaris	Insecta/Bombylius major
Mollusca/Limacia cockerelli	Insecta/Argynnis paphia	Aves/Cephus columba
Mammalia/Arctocephalus forsteri	Aves/Cathartes fuscescens	Insecta/Estigmene acrea
Insecta/Panoquina ocola	Reptilia/Aspidoscelis exsanguis	Reptilia/Pseudemys texana
Mammalia/Ondatra zibethicus	Reptilia/Sternotherus odoratus	Aves/Setophaga dominica
Insecta/Brephidium exilis	Aves/Larus argentatus	Insecta/Argia nahuana
Mammalia/Otospermophilus beecheyi	Reptilia/Eretmochelys imbricata	Reptilia/Podarcis muralis
Insecta/Libellula luctuosa	Aves/Sternula antillarum	Aves/Turdus merula
Insecta/Enallagma signatum	Aves/Salpinctes obsoletus	Aves/Alauda arvensis
Insecta/Popillia japonica	Aves/Sturnella neglecta	Reptilia/APalone spinifera
Insecta/Alaus oculatus	Insecta/Phyciodes pulchella	Reptilia/Sceloporus uniformis
Insecta/Dione moneta	Insecta/Bombus vosnesenskii	Aves/Thryomanes bewickii
Reptilia/Trachemys scripta	Insecta/Calopteryx maculata	Aves/Corvus cornix
Aves/Geothlypis trichas	Insecta/Pyrrharctia isabella	Arachnida/Argiope trifasciata
Aves/Aechmophorus occidentalis	Mammalia/Eschrichtius robustus	Aves/Haemorhous cassini
	Mammalia/Loxodonta africana	Insecta/Pieris marginalis

Animalia/Harpaphe haydeniana	Aves/Calidris bairdii	Insecta/Polistes dominula
Aves/Anthus rubescens	Insecta/Poanes hobomok	Aves/Sayornis phoebe
Insecta/Argia tibialis	Insecta/Polistes metricus	Aves/Phalacrocorax carbo
Reptilia/Sceloporus occidentalis bo-	Amphibia/Gastrophryne olivacea	Actinopterygii/Oncorhynchus mykiss
courtii	Aves/Setophaga americana	Insecta/Ischnura ramburii
Amphibia/Anaxyrus americanus	Aves/Icterus pustulatus	Aves/Callipepla gambelii
Reptilia/Sceloporus olivaceus	Aves/Coccothraustes vespertinus	Insecta/Melanchoria chephise
Insecta/Manduca sexta	Insecta/Microcrambus elegans	Insecta/Erynnis baptisiae
Aves/Psaltriparus minimus	Aves/Sphyrapicus ruber	Aves/Psittacula krameri
Aves/Callipepla squamata	Aves/Megaceryle alcyon	Aves/Piranga ludoviciana
Insecta/Galgula partita	Aves/Phalacrocorax pelagicus	Aves/Lophodytes cucullatus
Aves/Oreothlypis ruficapilla	Insecta/Leptoglossus occidentalis	Aves/Setophaga pinus
Aves/Paroaria coronata	Aves/Bucephala albeola	Reptilia/Hypsilema jani
Aves/Dendrocygna autumnalis	Aves/Dendrocopos major	Insecta/Graphocephala coccinea
Aves/Larus canus	Mammalia/Eidolon helvum	Amphibia/Hyla arenicolor
Reptilia/Callisaurus draconoides	Mammalia/Ovis canadensis	Insecta/Zerene cesonia
Animalia/Anthopleura elegantissima	Insecta/Erythrodiplax umbrata	Insecta/Lerema accius
Aves/Colinus virginianus	Insecta/Bombus pensylvanicus	Aves/Melanerpes erythrocephalus
Insecta/Limenitis arthemis arthemis	Aves/Pavo cristatus	Insecta/Prosapia bicincta
Mammalia/Callospermophilus later-	Aves/Tachybaptus dominicus	Insecta/Libellula needhami
alis	Insecta/Celastrina echo	Aves/Anas rubripes
Insecta/Cicindela sexguttata	Amphibia/Ensatina eschscholtzii	Insecta/Vanessa gonerilla gonerilla
Aves/Pachyramphus aglaiae	Aves/Myiarchus crinitus	Mollusca/Triopha maculata
Insecta/Xylocopa micans	Aves/Gavia pacifica	Insecta/Libellula semifasciata
Insecta/Ischnura verticalis	Insecta/Argia vivida	Aves/Zonotrichia querula
Reptilia/Crotalus ruber	Aves/Ixoreus naevius	Mollusca/Phidiana hiltoni
Aves/Anas clypeata	Aves/Pluvialis squatarola	Mammalia/Trichosurus vulpecula
Aves/Nyctanassa violacea	Amphibia/Rana draytonii	Reptilia/Thamnophis marcianus
Aves/Cardellina pusilla	Actinopterygii/Gambusia affinis	Insecta/Leptotes marina
Insecta/Dythemis nigrescens	Aves/Setophaga townsendi	Amphibia/Aneides lugubris
Aves/Hemiphaga novaeseelandiae	Mollusca/Doris montereyensis	Aves/Anas penelope
Aves/Passerculus sandwichensis	Aves/Motacilla alba	Amphibia/Lithobates clamitans
Insecta/Battus philenor hirsuta	Aves/Quiscalus major	Insecta/Colias eurytheme
Aves/Egretta garzetta	Aves/Eudocimus albus	Aves/Haematopus unicolor
Aves/Chaetura pelagica	Insecta/Lerodea eufala	Aves/Zonotrichia capensis
Insecta/Polygonia satyrus	Insecta/Schistocerca nitens	Aves/Parkesia motacilla
Insecta/Dythemis velox	Aves/Chroicocephalus scopulinus	Reptilia/Nerodia erythrogaster
Aves/Setophaga ruticilla	Insecta/Hemiargus ceraunus	Aves/Mimus gilvus
Aves/Setophaga magnolia	Aves/Spizella pallida	Mollusca/Calliostoma ligatum
Insecta/Poanes melane	Reptilia/Chelonia mydas	Aves/Empidonax difficilis
Aves/Buteogallus anthracinus	Insecta/Halyomorpha halys	Aves/Melozone fusca
Aves/Sterna hirundo	Insecta/Perithemis tenera	Aves/Aimophila ruficeps
Animalia/Tetraclita rubescens	Aves/Megaceryle torquata	Reptilia/Nerodia sipedon sipedon
Insecta/Argia lugens	Insecta/Polygonia c-album	Mammalia/Lepus californicus
Reptilia/Elgaria multicarinata webbii	Reptilia/Crocodylus acutus	Insecta/Lycaena phlaeas
Reptilia/Sceloporus graciosus	Aves/Uria aalge	Mammalia/Mephitis mephitis
Aves/Saxicola rubetra	Aves/Columbina passerina	Reptilia/Thamnophis sirtalis
Insecta/Trimerotropis pallidipennis	Aves/Cygnus buccinator	Insecta/Uresiphita reversalis
Reptilia/Coluber flagellum	Aves/Megascops asio	Aves/Calidris alpina
Aves/Setophaga palmarum	Aves/Sula leucogaster	Insecta/Pyrisitia lisa
Amphibia/Taricha torosa	Aves/Circus cyaneus	Aves/Sitta pygmaea
Insecta/Melanoplus differentialis	Insecta/Limenitis lorquini	Mammalia/Myocastor coypus
Mollusca/Ambigolimax valentianus	Aves/Gymnorhina tibicen	Aves/Gavia stellata

Aves/Aechmophorus clarkii		Aves/Prosthemadera novaeseelandiae		Aves/Oreothlypis celata
Actinopterygii/Cyprinus carpio		novaeseelandiae		Mammalia/Cynomys ludovicianus
Reptilia/Sceloporus graciosus vandenburghianus		Reptilia/Pantherophis obsoletus		Insecta/Halysidota tessellaris
Insecta/Anthocharis sara		Insecta/Chlosyne palla		Insecta/Arilus cristatus
Aves/Anhinga anhinga		Aves/Phalacrocorax brasilianus		Insecta/Erynnis funeralis
Insecta/Erythemis collocata		Aves/Himantopus himantopus		Insecta/Coenonympha pamphilus
Amphibia/Pseudacris crucifer		Mammalia/Enhydra lutris		Aves/Eupsittula canicularis
Reptilia/Terrapene carolina		Aves/Numenius americanus		Insecta/Vanessa cardui
Mollusca/Geitodoris heathi		Aves/Melanitta perspicillata		Aves/Myiozetetes similis
Mammalia/Sciurus aureogaster		Mammalia/Sus scrofa		Insecta/Libellula quadrimaculata
Reptilia/Aspidoscelis tigris		Aves/Carduelis cannabina		Insecta/Acanthocephala terminalis
Insecta/Idia aemula		Aves/Podiceps nigricollis		Aves/Anthornis melanura
Aves/Icterus galbula		Aves/Cinclus mexicanus		Insecta/Papilio machaon
Reptilia/Sceloporus occidentalis longipes		Reptilia/Terrapene carolina carolina		Aves/Rupornis magnirostris
Aves/Larus marinus		Insecta/Phyciodes phaon		Mammalia/Dasyurus novemcinctus
Insecta/Libellula saturata		Aves/Anas americana		Aves/Buteo buteo
Reptilia/Anolis sagrei		Aves/Tachycineta thalassina		Aves/Troglodytes pacificus
Reptilia/Pituophis catenifer		Insecta/Celastrina neglecta		Reptilia/Sceloporus consobrinus
Aves/Xanthocephalus xanthocephalus		Aves/Archilochus colubris		Reptilia/Nerodia fasciata confluens
Aves/Sitta europaea		Aves/Chamaea fasciata		Insecta/Euptoieta claudia
Insecta/Leptoglossus phyllopus		Insecta/Sympetrum ambiguum		Aves/Chroicocephalus philadelphia
Aves/Regulus calendula		Insecta/Eristalis tenax		Reptilia/Rena dulcis
Reptilia/Micrurus tener		Aves/Tyto alba		Aves/Fregata magnificens
Actinopterygii/Ostracion meleagris		Aves/Somateria mollissima		Aves/Setophaga pensylvanica
Aves/Catherpes mexicanus		Aves/Setophaga coronata coronata		Insecta/Hemaris diffinis
Aves/Plectrophenax nivalis		Aves/Spizella passerina		Reptilia/Elgaria multicarinata
Mollusca/Peltodoris nobilis		Reptilia/Agkistrodon piscivorus		Aves/Patagioenas fasciata
Reptilia/Urosaurus ornatus		Aves/Turdus rufopalliatus		Aves/Pheucticus ludovicianus
Reptilia/Zootoca vivipara		Insecta/Erythrodiplax berenice		Aves/Setophaga striata
Aves/Fulica atra		Reptilia/Crotalus atrox		Aves/Larus fuscus
Amphibia/Osteopilus septentrionalis		Reptilia/Elgaria multicarinata multicarinata		Insecta/Enallagma carunculatum
Insecta/Haematopis grataria		Aves/Falco peregrinus		Insecta/Alypia octomaculata
Aves/Aphelocoma wollweberi		Aves/Melanerpes formicivorus		Reptilia/Plestiodon laticeps
Mammalia/Vulpes vulpes		Insecta/Libellula incesta		Arachnida/Latrodectus geometricus
Insecta/Olla v-nigrum		Insecta/Marpesia petreus		Actinopterygii/Micropterus salmoides
Aves/Anas platyrhynchos diazi		Aves/Milvus milvus		Aves/Asio otus
Aves/Icteria virens		Mollusca/Otala lactea		
Insecta/Erythemis vesiculosa		Insecta/Heliconius charithonia		
Insecta/Siproeta stelenes		Reptilia/Storeria dekayi texana		
Aves/Sayornis saya		Amphibia/Acris blanchardi		
Aves/Podiceps grisegena		Insecta/Antheraea polyphemus		
Aves/Leptotila verreauxi		Mammalia/Taxidea taxus		
Aves/Toxostoma rufum		Insecta/Cisseps fulvicollis		
Aves/Podiceps cristatus		Aves/Seiurus aurocapilla		
Aves/Aythya affinis		Reptilia/Gopherus berlandieri		
Aves/Melospiza georgiana		Mollusca/Aplysia californica		
Reptilia/Uta stansburiana		Aves/Myiopsitta monachus		
Insecta/Libellula pulchella		Mammalia/Sylvilagus bachmani		
Insecta/Odontotaenius disjunctus		Aves/Poecile gambeli		
Aves/Coragyps atratus		Mammalia/Odocoileus hemionus columbianus		
		Reptilia/Cophosaurus texanus		