Few-Shot Learning with Localization in Realistic Settings (Supplementary Materials)

Note: Code for the models and main results of the paper are available at https://github.com/daviswer/fewshotlocal.

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.

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

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.

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

2. Network Architectures

Our learner architectures mimic the original prototypical networks. Networks contain four 64-channel 3×3 convolutional layers, with Batchnorm, ReLU, and 2×2 max-pooling in between. This is followed by Batchnorm and 10×10 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 28×28 feature maps with 512 channels. Learned layers consist of 2×2 max-pooling, followed by 3×3 convolution with 128 channels, Batchnorm, ReLU, a second 3×3 convolution with 64 channels, and Batchnorm. The resulting 14×14 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. 10×10), we use 4×4 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.

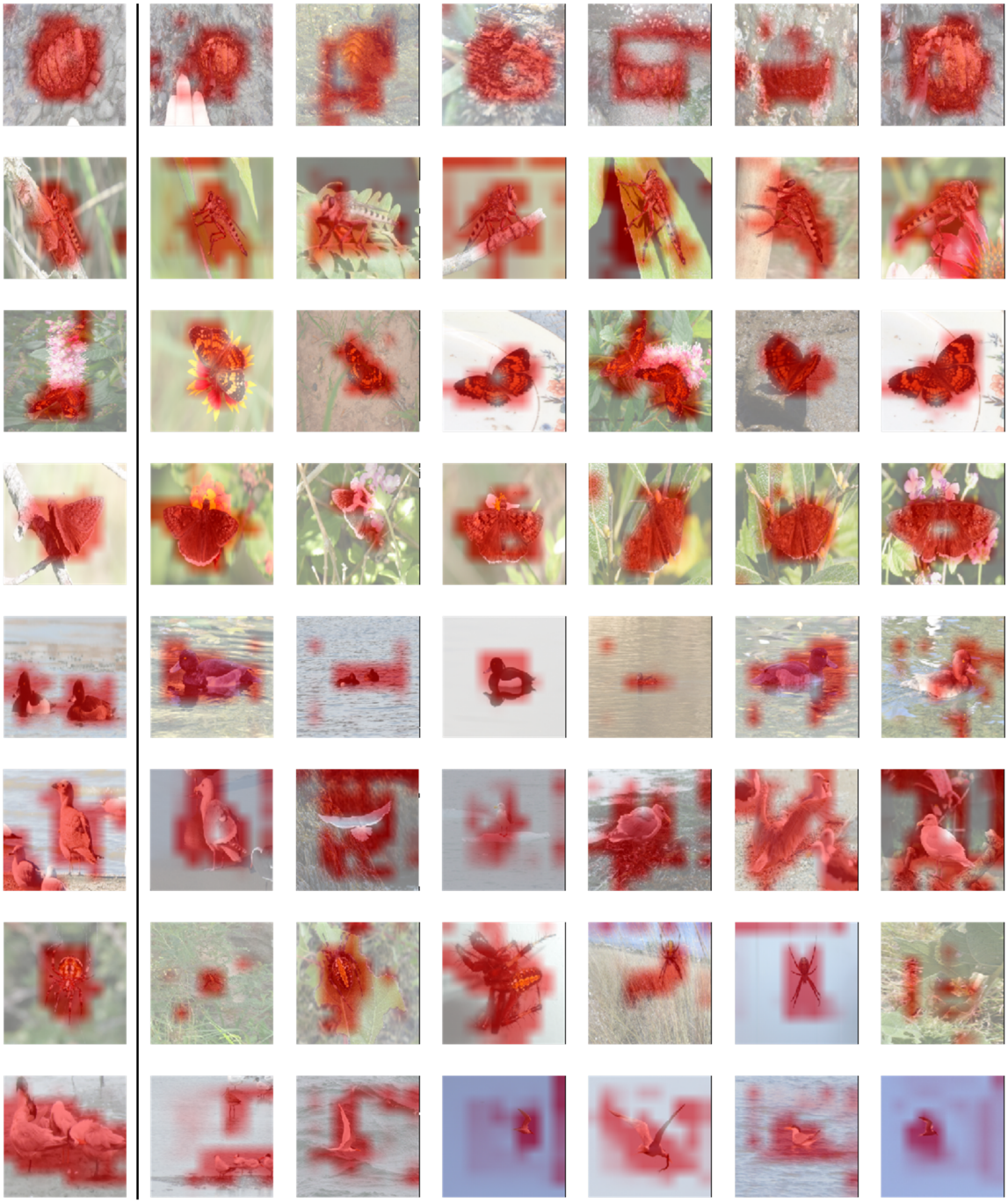
During testing, we wish to evaluate classification accuracy for relatively large numbers of classes and images. For sufficiently high values, it becomes impossible to process the sampled datasets as single batches in computer memory. Category sizes also vary so widely that it no longer makes sense to 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.

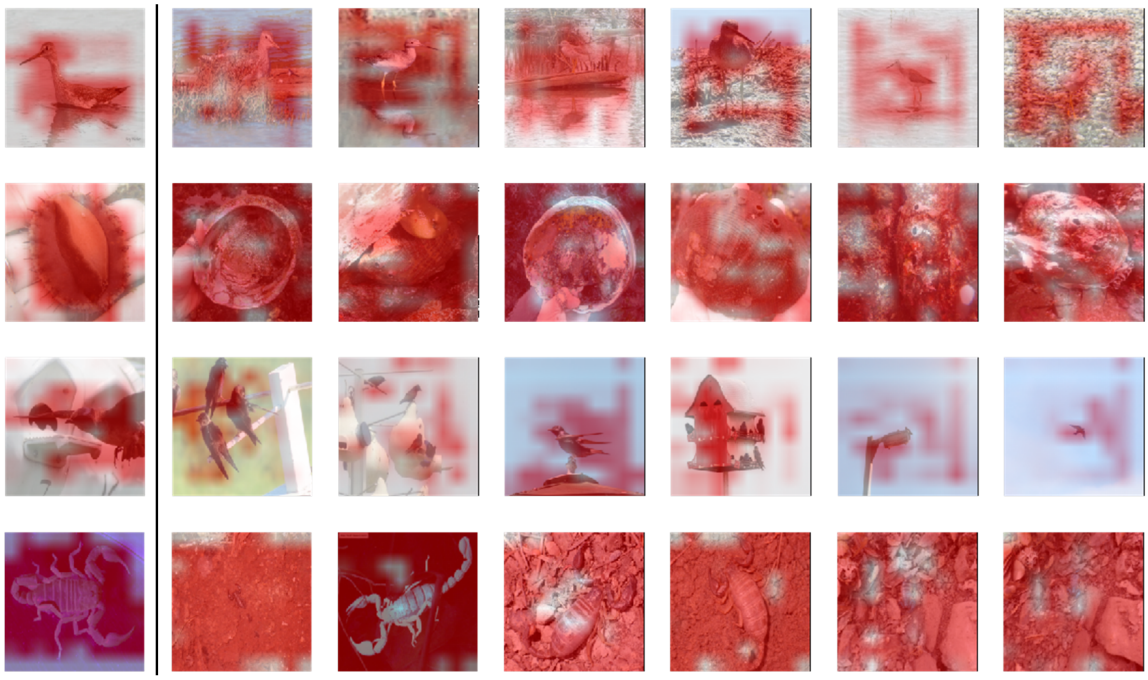
4. Additional Few-Shot Localization Examples

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 10×10 outputs and no localization supervision). The leftmost image provides the ground truth bounding box(es).

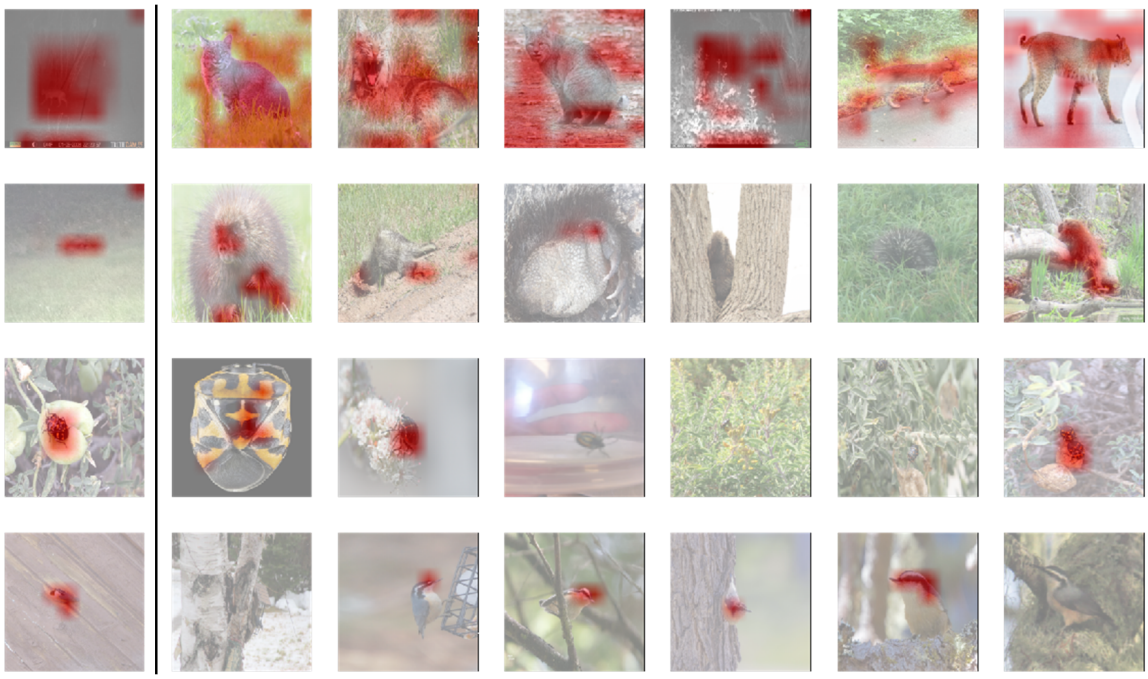


4.1. Failure cases

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.



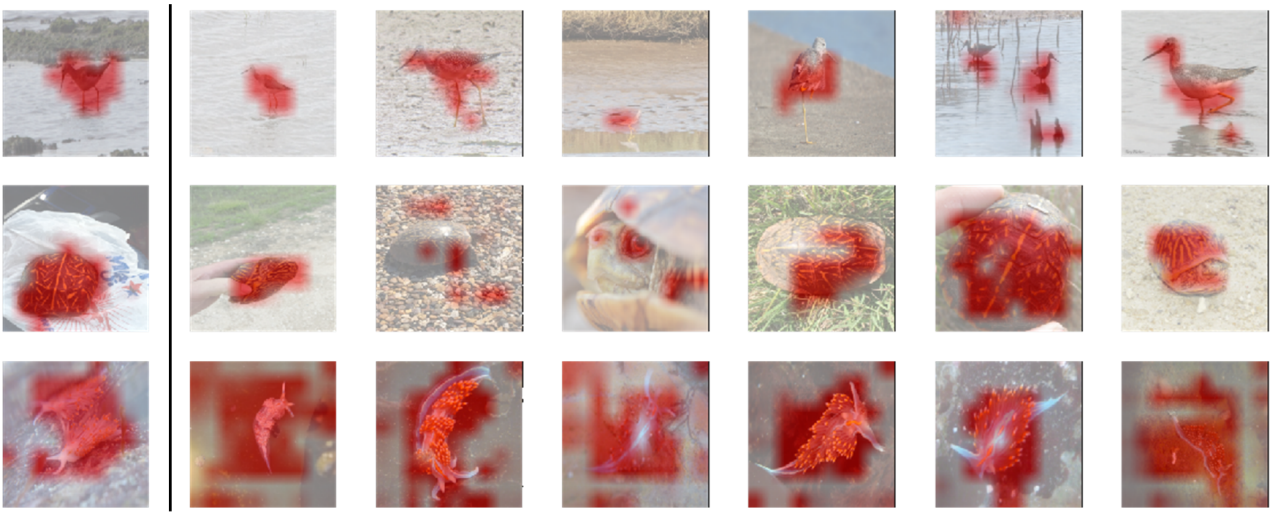
When bounding boxes are too small, the localizer focuses on the wrong things, selects small parts of the object in question, or in some cases fails to detect a region of interest at all.



4.2. Additional annotations

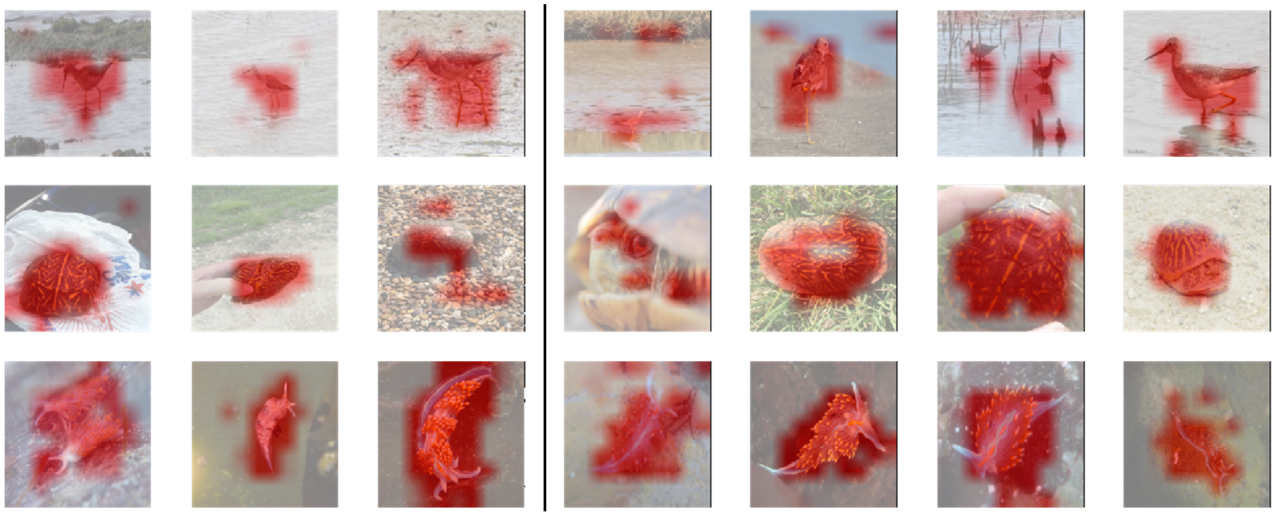
Localizer performance generally improves as more annotations are made available.

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

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

Representation Categories

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

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

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

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

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

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