

Bird Identification Database

Introduction

This database stores data that can be used to determine the probability of finding any species (I thought of birds) based upon location, time-of-day, and season, as provided by the user, and historical records of sightings. It is also possible to include characteristics of the species, such as color, size, shape, song, and behavior to help identification. A small addition allows the use to record actual sightings.

The model illustrates a use for Object Role Modeling (ORM). Full description of that technique and the notation are available here: <http://www.ORMfoundation.org>

Occurrence

The crux of the data is the occurrence probability, as shown below:

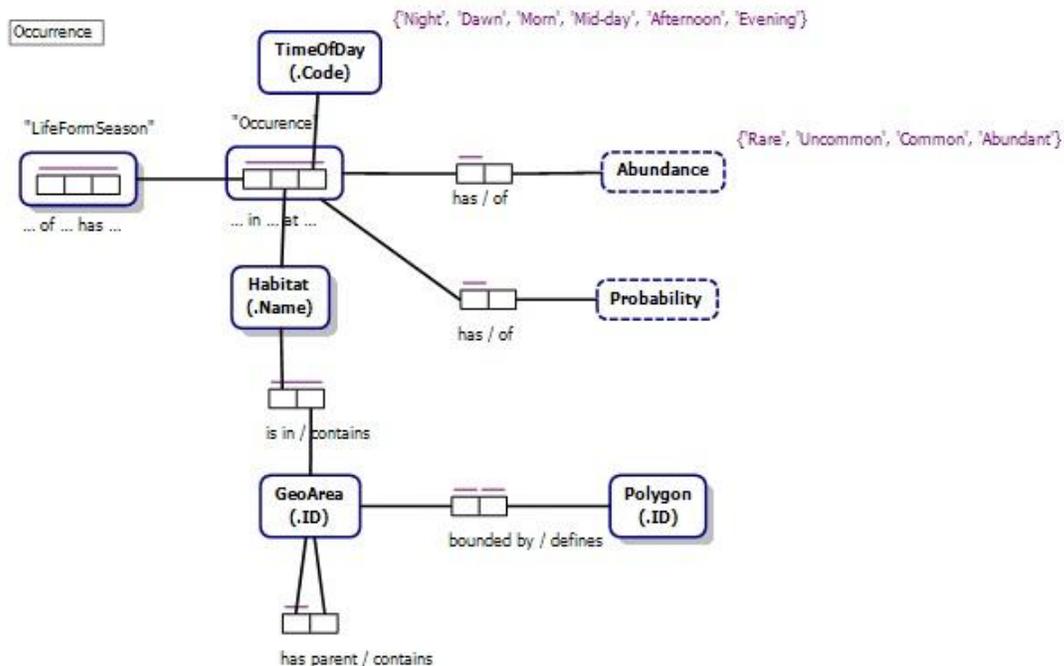


Figure 1 Species Occurrence

Abundance is a value type.
Portable data type: Text: Fixed Length.

Fact Types:

Occurrence has Abundance.

The possible values of Abundance are 'Rare', 'Uncommon', 'Common', 'Abundant'.

Informal Description: Abundance represents the number of individuals that might be observed. For birds

(as an example) some species are likely to be seen as individuals. Others in small flocks or large flocks. For some locations, birds that are normally seen as individuals might be grouped in large numbers, as in a heron rookery.

Age Class of LifeForm has Season.

Informal Description: Some Life Forms change appearance and voice. This may occur seasonally or as the organism ages.

It is possible that more than one Age Class of **the same** LifeForm has **the same** Season **and that the same** Age Class of **more than one** LifeForm has **the same** Season **and that more than one** Season of **the same** Age Class for **the same** LifeForm.

In each population of Age Class of LifeForm has Season, **each** Age Class, LifeForm, Season **combination occurs at most once.**

This association with Age Class, LifeForm, Season **provides the preferred identification scheme for** LifeFormSeason.

GeoArea bounded by Polygon.

Each GeoArea bounded by **at most one** Polygon.

Each Polygon defines **at most one** GeoArea.

GeoArea has parent GeoArea.

Each GeoArea has parent **at most one** GeoArea.

It is possible that the same GeoArea contains **more than one** GeoArea.

GeoArea **is an entity type.**

Reference Scheme: GeoArea has GeoArea_ID.

Reference Mode: .ID.

Fact Types:

GeoArea has GeoArea_ID.

Habitat is in GeoArea.

GeoArea has parent GeoArea.

GeoArea bounded by Polygon.

Informal Description: a demarcated area of the Earth.

Habitat **is an entity type.**

Reference Scheme: Habitat has Habitat_Name.

Reference Mode: .Name.

Fact Types:

Habitat has Habitat_Name.

Observation seen in Habitat.

Habitat has HabitatDescription.

Habitat is in GeoArea.

LifeFormSeason feeds in Habitat.

LifeFormSeason in Habitat at TimeOfDay.

Informal Description: Habitat: the natural environment of an organism; place that is natural for the life and growth of an organism. the place where a person or thing is usually found. The area or environment where an organism or ecological community normally lives or occurs.

Habitat is in GeoArea.

It is possible that more than one Habitat is in **the same** GeoArea **and that more than one** GeoArea contains **the same** Habitat.

In each population of Habitat is in GeoArea, **each** GeoArea, Habitat **combination occurs at most once.**

This association with GeoArea, Habitat **provides the preferred identification scheme for** HabitatGeography.

LifeFormSeason in Habitat at TimeOfDay.

Informal Description: Occurrence of a species is dependent upon the season (date), time of day (relative to sun-up and sun-down, not the clock!), and geographic location (which determines habitat at the most local). A GPS receiver can provide date, time of day, and location. Ground cover maps can provide habitat. Historic observations can provide probability of occurrence (or at least of observation).

It is possible that more than one LifeFormSeason **in the same** Habitat **at the same** TimeOfDay **and that the same** LifeFormSeason **in more than one** Habitat **at the same** TimeOfDay **and that the same** LifeFormSeason **in the same** Habitat **at more than one** TimeOfDay. **In each population of** LifeFormSeason **in** Habitat **at** TimeOfDay, **each** TimeOfDay, Habitat, LifeFormSeason **combination occurs at most once.**
This association with TimeOfDay, Habitat, LifeFormSeason **provides the preferred identification scheme for** Occurrence.

Notes: Occurrence.

Occurrence has Abundance.

Each Occurrence has **at most one** Abundance.

It is possible that the same Abundance of **more than one** Occurrence.

Occurrence has Probability.

Each Occurrence has **at most one** Probability.

It is possible that the same Probability of **more than one** Occurrence.

Polygon **is an entity type.**

Reference Scheme: Polygon has Polygon_ID.

Reference Mode: .ID.

Fact Types:

GeoArea bounded by Polygon.

Polygon has Node in Sequence.

Polygon has Polygon_ID.

Arc bounded by left Polygon and right Polygon.

Polygon describes Layer.

Informal Description: a figure, especially a closed plane figure, having three or more, usually straight, sides. Polygons are defined by arcs. To define a given polygon, trace around its area in a clockwise direction recording the component arcs and their orientations. If an arc has to be followed in its reverse orientation to make the tracing, it is assigned a negative sign in the database.

Probability **is a value type.**

Portable data type: Numeric: Unsigned Tiny Integer.

Fact Types:

Occurrence has Probability.

Informal Description: Probability represents the chance that an observer might find this species.

Expressed as percentage 0-100. the relative possibility that an event will occur, as expressed by the ratio of the number of actual occurrences to the total number of possible occurrences.

TimeOfDay **is an entity type.**

Reference Scheme: TimeOfDay has TimeOfDay_Code.

Reference Mode: .Code.

Fact Types:

TimeOfDay has TimeOfDay_Code.

LifeFormSeason in Habitat at TimeOfDay.

Informal Description: Time of Day is a named period. Typical values would be Night, Mid-Day, Morning, Evening.

Notes: Time of Day derives from the date, time, and latitude.

The possible values of TimeOfDay **are** 'Night', 'Dawn', 'Morn', 'Mid-day', 'Afternoon', 'Evening'.

Observation

Once you have the date, time, and species, recording this is simple, as shown below:

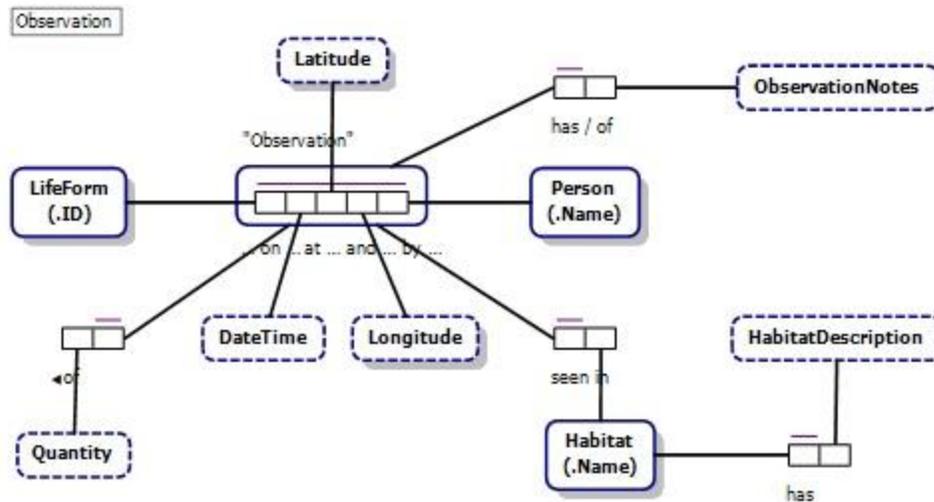


Figure 2 Observation Record

DateTime is a value type.

Portable data type: Temporal: Date & Time.

Fact Types:

LifeForm on DateTime at Latitude and Longitude by Person.

Habitat has HabitatDescription.

Each Habitat has at most one HabitatDescription.

It is possible that more than one Habitat has the same HabitatDescription.

Habitat is an entity type.

Reference Scheme: Habitat has Habitat_Name.

Reference Mode: .Name.

Fact Types:

Habitat has Habitat_Name.

Observation seen in Habitat.

Habitat has HabitatDescription.

Habitat is in GeoArea.

LifeFormSeason feeds in Habitat.

LifeFormSeason in Habitat at TimeOfDay.

Informal Description: *Habitat: the natural environment of an organism; place that is natural for the life and growth of an organism. the place where a person or thing is usually found. The area or environment where an organism or ecological community normally lives or occurs.*

HabitatDescription is a value type.

Portable data type: Text: Variable Length.

Fact Types:

Habitat has HabitatDescription.

Latitude is a value type.

Portable data type: Numeric: Float (Double Precision).

Fact Types:

LifeForm on DateTime at Latitude and Longitude by Person.

Node consists of Latitude plus Longitude plus Altitude.

Informal Description: *the angular distance north or south from the equator of a point on the earth's surface, measured on the meridian of the point.*

LifeForm is an entity type.

Reference Scheme: LifeForm has LifeForm_ID.

Reference Mode: .ID.

Fact Types:

LifeForm has LifeForm_ID.

LifeForm on DateTime at Latitude and Longitude by Person.

LifeForm has Movement Description.

LifeForm has CommonName.

LifeForm has Nesting Description.

LifeForm has Length.

LifeForm has Width.

LifeForm has Weight.

LifeForm in Locale (.Name) has common/of Name.

Age Class of LifeForm has Season.

LifeForm has/of TaxonomicName at/of TaxonomyLevel.

LifeForm similar to LifeForm.

Informal Description: *a form of life composed of mutually interdependent parts that maintain various vital processes. an Organism. An individual form of life, such as a plant, animal, bacterium, protist, or fungus; a body made up of organs, organelles, or other parts that work together to carry on the various processes of life. This was conceived for birds, but reasonably applies to any animal or plant, with a few exceptions!.*

LifeForm on DateTime at Latitude and Longitude by Person.

Informal Description: *an act or instance of viewing or noting a fact or occurrence for some scientific or other special purpose.*

It is possible that more than one LifeForm on the same DateTime at the same Latitude and the same Longitude by the same Person

and that the same LifeForm on more than one DateTime at the same Latitude and the same Longitude by the same Person

and that the same LifeForm on the same DateTime at more than one Latitude and the same Longitude by the same Person

and that the same LifeForm on the same DateTime at the same Latitude and more than one Longitude by the same Person

and that the same LifeForm on the same DateTime at the same Latitude and the same Longitude by more than one Person.

In each population of LifeForm on DateTime at Latitude and Longitude by Person, each Person, Longitude, Latitude, DateTime, LifeForm combination occurs at most once.

This association with Person, Longitude, Latitude, DateTime, LifeForm provides the preferred identification scheme for Observation.

Longitude is a value type.

Portable data type: Numeric: Float (Double Precision).

Fact Types:

LifeForm on DateTime at Latitude and Longitude by Person.

Node consists of Latitude plus Longitude plus Altitude.

Informal Description: *angular distance east or west on the earth's surface, measured by the angle contained between the meridian of a particular place and some prime meridian, as that of Greenwich, England, and expressed either in degrees or by some corresponding difference in time.*

Notes: Observation.

Observation has ObservationNotes.

Each Observation has **at most one** ObservationNotes.

It is possible that the same ObservationNotes of **more than one** Observation.

Observation of Quantity.

Each Observation of **at most one** Quantity.

It is possible that more than one Observation of **the same** Quantity.

Observation seen in Habitat.

Each Observation seen in **at most one** Habitat.

It is possible that more than one Observation seen in **the same** Habitat.

ObservationNotes is a value type.

Portable data type: Text: Variable Length.

Fact Types:

Observation has ObservationNotes.

Person is an entity type.

Reference Scheme: Person has Person_Name.

Reference Mode: .Name.

Fact Types:

Person has Person_Name.

LifeForm on DateTime at Latitude and Longitude by Person.

Person plays Role in Illustration.

Informal Description: *Person is normally the observer, but could also be any human.*

Quantity is a value type.

Portable data type: Numeric: Unsigned Tiny Integer.

Fact Types:

Observation of Quantity.

Informal Description: *Quantity is the number of organisms observed at this location and time.*

Life Form Attributes

This is a description of the species (“life form”, or bird). You may notice that some attributes vary with season (winter, summer, breeding) and with age class (juvenile, first year, second year).

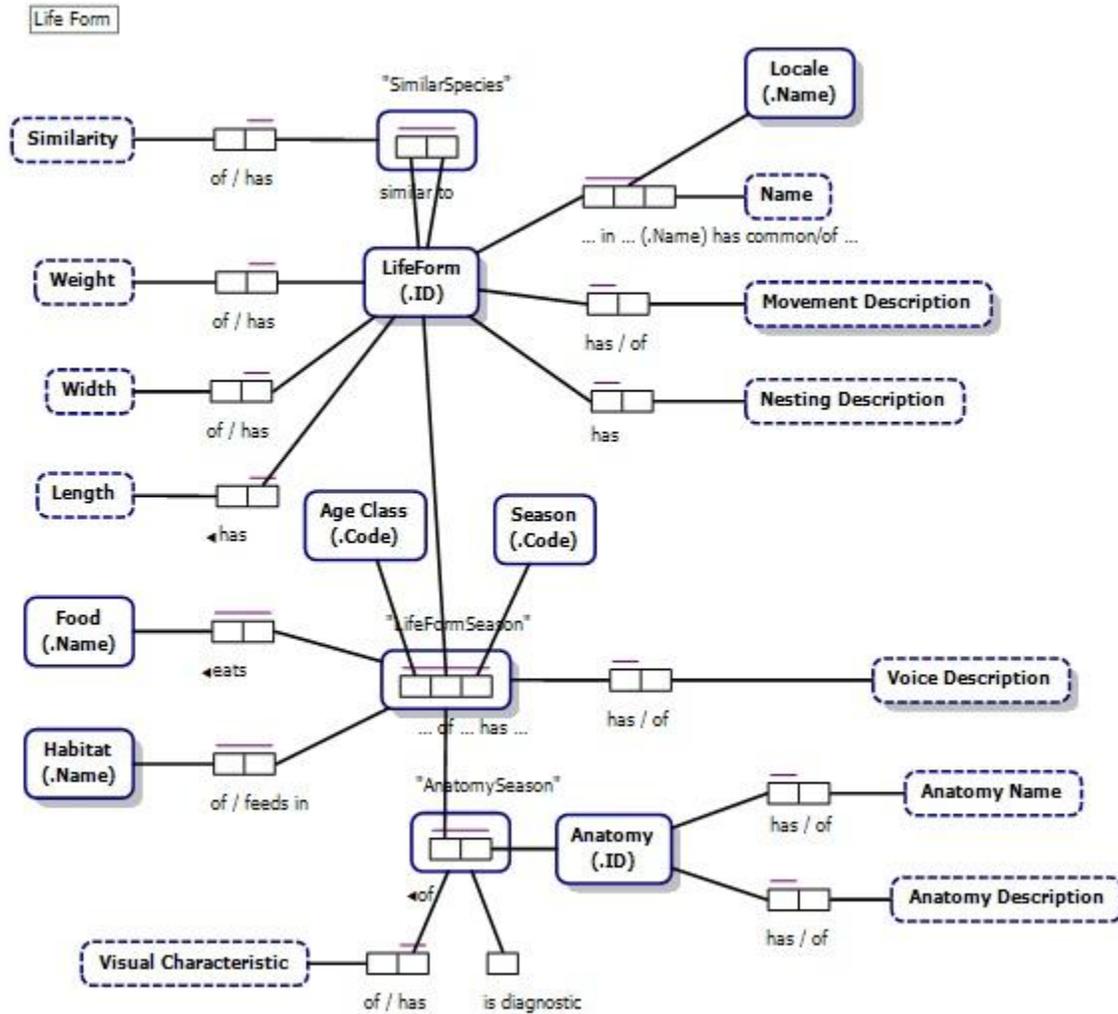


Figure 3 Life Form Attributes

Age Class is an entity type.

Reference Scheme: Age Class has Age Class_Code.

Reference Mode: .Code.

Fact Types:

Age Class has Age Class_Code.

Age Class of LifeForm has Season.

Informal Description: Age classification, such as breeding, fledgling, first year, adult.

Age Class of LifeForm has Season.

Informal Description: Some Life Forms change appearance and voice. This may occur

seasonally or as the organism ages.

It is possible that more than one Age Class of the same LifeForm has the same Season and that the same Age Class of more than one LifeForm has the same Season and that more than one Season of the same Age Class for the same LifeForm.

In each population of Age Class of LifeForm has Season, each Age Class, LifeForm, Season combination occurs at most once.

This association with Age Class, LifeForm, Season provides the preferred identification scheme for LifeFormSeason.

Anatomy Description is a value type.

Portable data type: Text: Variable Length.

Fact Types:

Anatomy has Anatomy Description.

Anatomy has Anatomy Description.

Each Anatomy has at most one Anatomy Description.

It is possible that the same Anatomy Description of more than one Anatomy.

Anatomy has Anatomy Name.

Informal Description: *Name of the anatomy part. Could be extended to add dependency on locale for local names in various languages.*

Each Anatomy has at most one Anatomy Name.

It is possible that the same Anatomy Name of more than one Anatomy.

Anatomy is an entity type.

Reference Scheme: Anatomy has Anatomy_ID.

Reference Mode: .ID.

Fact Types:

Anatomy has Anatomy_ID.

Anatomy has Anatomy Name.

Anatomy has Anatomy Description.

Anatomy has Illustration.

Anatomy of LifeFormSeason.

Informal Description: *the structure of an animal or plant, or of any of its parts.*

Anatomy Name is a value type.

Portable data type: Text: Variable Length.

Fact Types:

Anatomy has Anatomy Name.

Anatomy of LifeFormSeason.

It is possible that more than one Anatomy of the same LifeFormSeason and that the same Anatomy of more than one LifeFormSeason.

In each population of Anatomy of LifeFormSeason, each LifeFormSeason, Anatomy combination occurs at most once.

This association with LifeFormSeason, Anatomy provides the preferred identification scheme for AnatomySeason.

AnatomySeason has Visual Characteristic.

Each AnatomySeason has **at most one** Visual Characteristic.

It is possible that the same Visual Characteristic of **more than one** AnatomySeason.

AnatomySeason is diagnostic.

In each population of AnatomySeason is diagnostic, **each** AnatomySeason **occurs at most once**.

Food is an entity type.

Reference Scheme: Food has Food_Name.

Reference Mode: .Name.

Fact Types:

Food has Food_Name.

LifeFormSeason eats Food.

Informal Description: *a particular kind of solid nourishment.*

Habitat is an entity type.

Reference Scheme: Habitat has Habitat_Name.

Reference Mode: .Name.

Fact Types:

Habitat has Habitat_Name.

Observation seen in Habitat.

Habitat has HabitatDescription.

Habitat is in GeoArea.

LifeFormSeason feeds in Habitat.

LifeFormSeason in Habitat at TimeOfDay.

Informal Description: *Habitat: the natural environment of an organism; place that is natural for the life and growth of an organism. the place where a person or thing is usually found. The area or environment where an organism or ecological community normally lives or occurs.*

Length is a value type.

Portable data type: Numeric: Unsigned Small Integer.

Fact Types:

LifeForm has Length.

Informal Description: *the longest extent of anything as measured from end to end. For birds and animals this is nose through tail.*

LifeForm has Length.

Each LifeForm has **at most one** Length.

It is possible that more than one LifeForm has **the same** Length.

LifeForm has Movement Description.

Each LifeForm has **at most one** Movement Description.

It is possible that the same Movement Description of **more than one** LifeForm.

LifeForm has Nesting Description.

Each LifeForm has **at most one** Nesting Description.

It is possible that more than one LifeForm has **the same** Nesting Description.

LifeForm has Weight.

Each LifeForm has **at most one** Weight.

It is possible that the same Weight of **more than one** LifeForm.

LifeForm has Width.

Each LifeForm has **at most one** Width.

It is possible that the same Width of **more than one** LifeForm.

LifeForm in Locale (.Name) has common/of Name.

For each Locale **and** LifeForm,

that LifeForm in **that** Locale (.Name) has common/of **at most one** Name.

This association with Locale, LifeForm **provides the preferred identification scheme for** LocalName.

LifeForm **is an entity type**.

Reference Scheme: LifeForm has LifeForm_ID.

Reference Mode: .ID.

Fact Types:

LifeForm has LifeForm_ID.

LifeForm on DateTime at Latitude and Longitude by Person.

LifeForm has Movement Description.

LifeForm has CommonName.

LifeForm has Nesting Description.

LifeForm has Length.

LifeForm has Width.

LifeForm has Weight.

LifeForm in Locale (.Name) has common/of Name.

Age Class of LifeForm has Season.

LifeForm has/of TaxonomicName at/of TaxonomyLevel.

LifeForm similar to LifeForm.

Informal Description: *a form of life composed of mutually interdependent parts that maintain various vital processes. an Organism. An individual form of life, such as a plant, animal, bacterium, protist, or fungus; a body made up of organs, organelles, or other parts that work together to carry on the various processes of life. This was conceived for birds, but reasonably applies to any animal or plant, with a few exceptions!.*

LifeForm similar to LifeForm.

It is possible that more than one LifeForm similar to **the same** LifeForm **and that the same** LifeForm similar to **more than one** LifeForm.

In each population of LifeForm similar to LifeForm, **each** LifeForm, LifeForm **combination occurs at most once**.

This association with LifeForm, LifeForm **provides the preferred identification scheme for** SimilarSpecies.

LifeFormSeason eats Food.

It is possible that more than one LifeFormSeason eats the same Food and that the same LifeFormSeason eats more than one Food.

In each population of LifeFormSeason eats Food, each Food, LifeFormSeason combination occurs at most once.

This association with Food, LifeFormSeason provides the preferred identification scheme for LifeFormFood.

LifeFormSeason feeds in Habitat.

It is possible that more than one LifeFormSeason feeds in the same Habitat and that more than one Habitat of the same LifeFormSeason.

In each population of LifeFormSeason feeds in Habitat, each Habitat, LifeFormSeason combination occurs at most once.

This association with Habitat, LifeFormSeason provides the preferred identification scheme for FeedingHabitat.

LifeFormSeason has Voice Description.

Each LifeFormSeason has at most one Voice Description.

It is possible that the same Voice Description of more than one LifeFormSeason.

Locale is an entity type.

Reference Scheme: Locale has Locale_Name.

Reference Mode: .Name.

Fact Types:

LifeForm in Locale (.Name) has common/of Name.

Locale has Locale_Name.

Illustration in Locale has Caption.

Informal Description: *The part of the world in which this caption or name is used.*

Notes: *Common species such as birds often have different local names. Also, captions and descriptions might be provided in different languages for different locales. (This is not fully modeled.).*

Movement Description is a value type.

Portable data type: Text: Variable Length.

Fact Types:

LifeForm has Movement Description.

Movement Description has Illustration.

Name is a value type.

Portable data type: Text: Variable Length.

Fact Types:

LifeForm in Locale (.Name) has common/of Name.

Informal Description: *a human identifier.*

Nesting Description is a value type.

Portable data type: Text: Variable Length.

Fact Types:

LifeForm has Nesting Description.

Notes: *Life Form.*

Season is an entity type.

Reference Scheme: Season has Season_Code.

Reference Mode: .Code.

Fact Types:

Season has Season_Code.

Date determines Season.

Age Class of LifeForm has Season.

Informal Description: *Season is the time of year. In the temperate zones this would be Winter, Spring, Summer, and Autumn. In the tropics it might be the wet season and the dry season. In some areas it would include monsoon season.*

Notes: *Season is derived from Date.*

The possible values of Season are 'Winter', 'Spring', 'Summer', 'Autumn'.

Similarity is a value type.

Portable data type: Text: Variable Length.

Fact Types:

SimilarSpecies has Similarity.

Informal Description: *Description of how the species are similar and/or different.*

SimilarSpecies has Similarity.

Each SimilarSpecies has at most one Similarity.

It is possible that the same Similarity of more than one SimilarSpecies.

Visual Characteristic is a value type.

Portable data type: Text: Variable Length.

Fact Types:

AnatomySeason has Visual Characteristic.

Informal Description: *a distinguishing feature or quality.*

Voice Description is a value type.

Portable data type: Text: Variable Length.

Fact Types:

LifeFormSeason has Voice Description.

Voice Description has Illustration.

Informal Description: *A text phoneme of the sound. E.g. "Chick-a-dee-dee-dee".*

Weight is a value type.

Portable data type: Numeric: Unsigned Small Integer.

Fact Types:

LifeForm has Weight.

Width is a value type.

Portable data type: Numeric: Unsigned Small Integer.

Fact Types:

LifeForm has Width.

Informal Description: The measurement of the extent of something from side to side.

Illustration

Many aspects can be illustrated, using pictures, video, photos, or charts. I have included only a few in the example below:

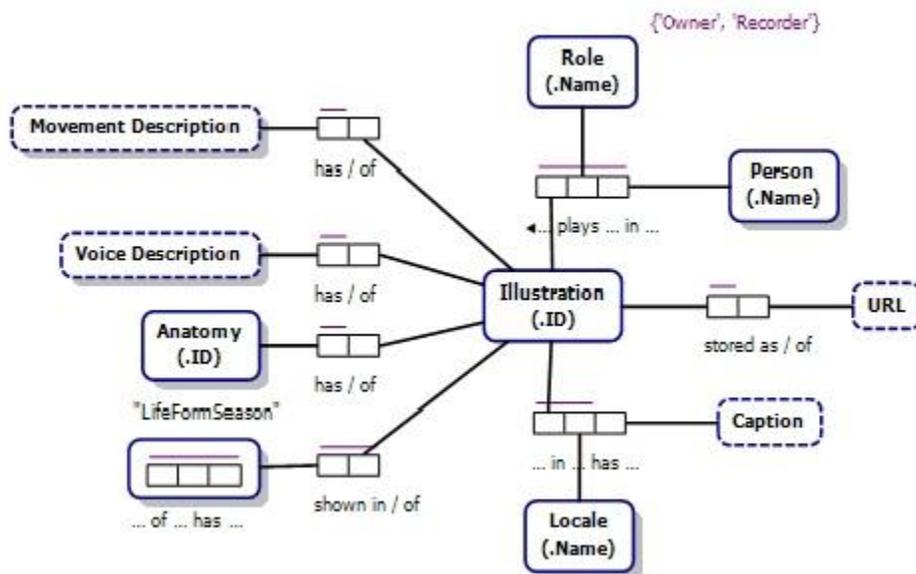


Figure 4 Illustration Data

Age Class of LifeForm has Season.

Informal Description: Some Life Forms change appearance and voice. This may occur seasonally or as the organism ages.

It is possible that more than one Age Class of the same LifeForm has the same Season and that the same Age Class of more than one LifeForm has the same Season and that more than one Season of the same Age Class for the same LifeForm.

In each population of Age Class of LifeForm has Season, each Age Class, LifeForm, Season combination occurs at most once.

This association with Age Class, LifeForm, Season provides the preferred identification scheme for LifeFormSeason.

Anatomy has Illustration.

Informal Description: I expect these illustrations would be drawings.

Each Anatomy has at most one Illustration.

It is possible that the same Illustration of more than one Anatomy.

Anatomy is an entity type.

Reference Scheme: Anatomy has Anatomy_ID.

Reference Mode: .ID.

Fact Types:

Anatomy has Anatomy_ID.

Anatomy has Anatomy Name.

Anatomy has Anatomy Description.

Anatomy has Illustration.

Anatomy of LifeFormSeason.

Informal Description: *the structure of an animal or plant, or of any of its parts.*

Caption is a value type.

Portable data type: Text: Variable Length.

Fact Types:

Illustration in Locale has Caption.

Informal Description: *Text explanation of the illustration.*

Illustration in Locale has Caption.

For each Illustration and Locale,

that Illustration in that Locale has at most one Caption.

This association with Illustration, Locale provides the preferred identification scheme for LocalCaption.

Illustration is an entity type.

Reference Scheme: Illustration has Illustration_ID.

Reference Mode: .ID.

Fact Types:

Illustration has Illustration_ID.

Illustration stored as URL.

Illustration in Locale has Caption.

Person plays Role in Illustration.

LifeFormSeason shown in Illustration.

Anatomy has Illustration.

Movement Description has Illustration.

Voice Description has Illustration.

Informal Description: *Illustration is any graphic, video, or audio representation of the LifeForm. something that illustrates, as a picture.*

Illustration stored as URL.

Each Illustration stored as at most one URL.

It is possible that the same URL of more than one Illustration.

LifeFormSeason shown in Illustration.

It is possible that more than one LifeFormSeason shown in the same Illustration and that more than one Illustration of the same LifeFormSeason.

In each population of LifeFormSeason shown in Illustration, each Illustration, LifeFormSeason combination occurs at most once.

This association with Illustration, LifeFormSeason provides the preferred identification scheme for LifeFormIllustration.

Locale is an entity type.

Reference Scheme: Locale has Locale_Name.

Reference Mode: .Name.

Fact Types:

LifeForm in Locale (.Name) has common/of Name.

Locale has Locale_Name.

Illustration in Locale has Caption.

Informal Description: *The part of the world in which this caption or name is used.*

Notes: *Common species such as birds often have different local names. Also, captions and descriptions might be provided in different languages for different locales. (This is not fully modeled.).*

Movement Description has Illustration.

Each Movement Description has **at most one** Illustration.

It is possible that the same Illustration of **more than one** Movement Description.

Movement Description **is a value type.**

Portable data type: Text: Variable Length.

Fact Types:

LifeForm has Movement Description.

Movement Description has Illustration.

Person is an entity type.

Reference Scheme: Person has Person_Name.

Reference Mode: .Name.

Fact Types:

Person has Person_Name.

LifeForm on DateTime at Latitude and Longitude by Person.

Person plays Role in Illustration.

Informal Description: *Person is normally the observer, but could also be any human.*

Person plays Role in Illustration.

It is possible that more than one Person plays **the same** Role in **the same** Illustration **and that the same** Person plays **more than one** Role in **the same** Illustration **and that the same** Person plays **the same** Role in **more than one** Illustration.

In each population of Person plays Role in Illustration, **each** Illustration, Role, Person combination occurs **at most once.**

This association with Illustration, Role, Person provides the preferred identification scheme for IllustrationRole.

Role is an entity type.

Reference Scheme: Role has Role_Name.

Reference Mode: .Name.

Fact Types:

Role has Role_Name.

Person plays Role in Illustration.

Informal Description: *The characteristic and expected social behavior of an individual. A function or position.*

The possible values of Role are 'Owner', 'Recorder'.

URL is a value type.

Portable data type: Text: Variable Length.

Fact Types:

Illustration stored as URL.

Informal Description: *Uniform Resource Locator - where the illustration can be found.*

Voice Description has Illustration.

Each Voice Description has at most one Illustration.

It is possible that the same Illustration of more than one Voice Description.

Voice Description is a value type.

Portable data type: Text: Variable Length.

Fact Types:

LifeFormSeason has Voice Description.

Voice Description has Illustration.

Informal Description: *A text phoneme of the sound. E.g. "Chick-a-dee-dee-dee".*

Taxonomy

This is the familiar **biological taxonomy** as developed by Linnaeus:

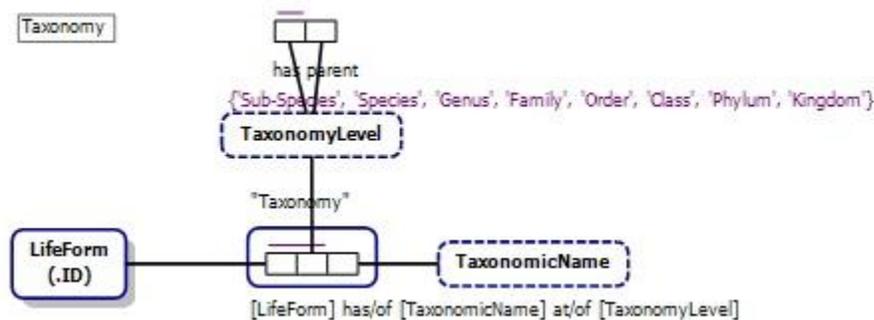


Figure 5 Hierarchical Taxonomy

LifeForm has/of TaxonomicName at/of TaxonomyLevel.

For each TaxonomyLevel and LifeForm,

that LifeForm has/of at most one TaxonomicName at/of that TaxonomyLevel.

This association with TaxonomyLevel, LifeForm provides the preferred identification scheme for Taxonomy.

LifeForm is an entity type.

Reference Scheme: LifeForm has LifeForm_ID.

Reference Mode: .ID.

Fact Types:

LifeForm has LifeForm_ID.
LifeForm on DateTime at Latitude and Longitude by Person.
LifeForm has Movement Description.
LifeForm has CommonName.
LifeForm has Nesting Description.
LifeForm has Length.
LifeForm has Width.
LifeForm has Weight.
LifeForm in Locale (.Name) has common/of Name.
Age Class of LifeForm has Season.
LifeForm has/of TaxonomicName at/of TaxonomyLevel.
LifeForm similar to LifeForm.

Informal Description: *a form of life composed of mutually interdependent parts that maintain various vital processes. an Organism. An individual form of life, such as a plant, animal, bacterium, protist, or fungus; a body made up of organs, organelles, or other parts that work together to carry on the various processes of life. This was conceived for birds, but reasonably applies to any animal or plant, with a few exceptions!.*

Notes: Taxonomy.

TaxonomicName **is a value type.**

Portable data type: Text: Variable Length.

Fact Types:

LifeForm has/of TaxonomicName at/of TaxonomyLevel.

TaxonomyLevel has parent TaxonomyLevel.

Each TaxonomyLevel has parent **at most one** TaxonomyLevel.

It is possible that more than one TaxonomyLevel has parent **the same** TaxonomyLevel.

TaxonomyLevel **is a value type.**

Portable data type: Text: Variable Length.

Fact Types:

LifeForm has/of TaxonomicName at/of TaxonomyLevel.

TaxonomyLevel has parent TaxonomyLevel.

The possible values of TaxonomyLevel **are** 'Sub-Species', 'Species', 'Genus', 'Family', 'Order', 'Class', 'Phylum', 'Kingdom'.

Geographical Information System (GIS)

There are two ways of storing GIS data: raster and vector. I have chosen the vector method, illustrated below:

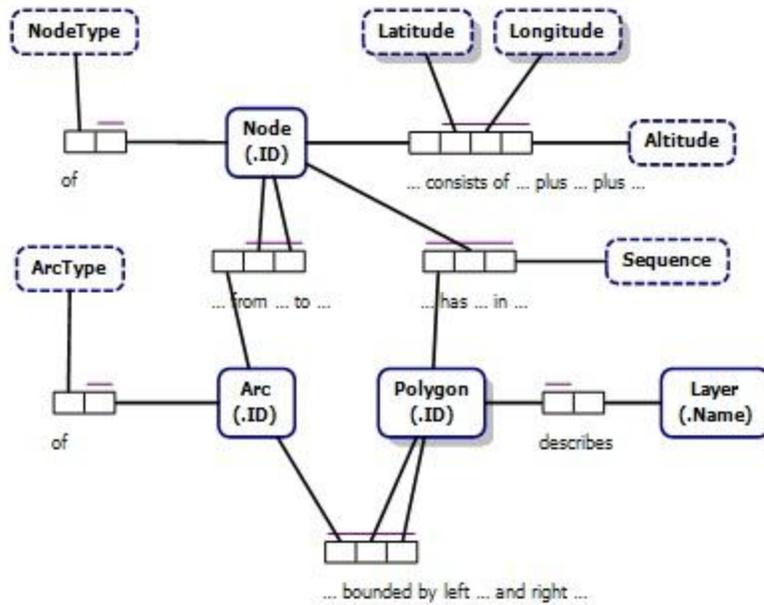


Figure 6 GIS Vector Data

Altitude is a value type.

Portable data type: Numeric: Float (Double Precision).

Fact Types:

Node consists of Latitude plus Longitude plus Altitude.

Arc bounded by left Polygon and right Polygon.

Informal Description: Contiguity records which polygon lies to the left and right side of its direction of orientation. If an arc is on the edge of the study area, it is bounded by the "universe".

It is possible that more than one Arc bounded by left **the same Polygon₁** and right **the same Polygon₂**

and that the same Arc bounded by left **more than one Polygon₁** and right **the same Polygon₂**

and that the same Arc bounded by left **the same Polygon₁** and right **more than one Polygon₂**

In each population of Arc bounded by left Polygon₁ and right Polygon₂, **each Arc, Polygon₁, Polygon₂ combination occurs at most once.**

This association with Arc, Polygon₁, Polygon₂ provides the preferred identification scheme for ArcBoundedByLeftPolygonAndRightPolygon.

Arc from Node to Node.

For each Node₁ and Node₂,

at most one Arc from **that Node₁** to **that Node₂**.

This association with Node₁, Node₂ provides the preferred identification scheme for ArcFromNodeToNode.

Arc is an entity type.

Reference Scheme: Arc has Arc_ID.

Reference Mode: .ID.

Fact Types:

Arc from Node to Node.

Arc has Arc_ID.

Arc bounded by left Polygon and right Polygon.

ArcType of Arc.

Informal Description: *any unbroken part of the circumference of a circle or other curved line. Arcs have endpoints, but they are also assigned a direction indicated by the arrowheads. The starting point of the vector is referred to as the "from node" and the destination the "to node." The orientation of a given vector can be assigned in either direction, as long as this direction is recorded and stored in the database.*

ArcType is a value type.

Portable data type: Text: Variable Length.

Fact Types:

ArcType of Arc.

Informal Description: *How the arc is interpreted. Examples: road, waterway, boundary.*

ArcType of Arc.

For each Arc, at most one ArcType of that Arc.

It is possible that the same ArcType of more than one Arc.

Latitude is a value type.

Portable data type: Numeric: Float (Double Precision).

Fact Types:

LifeForm on DateTime at Latitude and Longitude by Person.

Node consists of Latitude plus Longitude plus Altitude.

Informal Description: *the angular distance north or south from the equator of a point on the earth's surface, measured on the meridian of the point.*

Layer is an entity type.

Reference Scheme: Layer has Layer_Name.

Reference Mode: .Name.

Fact Types:

Layer has Layer_Name.

Polygon describes Layer.

Informal Description: *A GIS stores information about the world as a collection of thematic layers that can be linked together by geography. This simple but extremely powerful and versatile concept has proven invaluable for solving many real-world problems from tracking delivery vehicles, to recording details of planning applications, to modeling global atmospheric circulation. The thematic layer approach allows us to organize the complexity of the real world into a simple representation to help facilitate our understanding of natural relationships. [David J Buckley, The GIS Primer http://bgis.sanbi.org/gis-primer/page_01.htm].*

The possible values of Layer are 'Ownership', 'Geology', 'Land Cover', 'Soil Type'.

Longitude is a value type.

Portable data type: Numeric: Float (Double Precision).

Fact Types:

LifeForm on DateTime at Latitude and Longitude by Person.

Node consists of Latitude plus Longitude plus Altitude.

Informal Description: *angular distance east or west on the earth's surface, measured by the angle contained between the meridian of a particular place and some prime meridian, as that of Greenwich, England, and expressed either in degrees or by some corresponding difference in time.*

Node consists of Latitude plus Longitude plus Altitude.

For each Latitude, Longitude, **and** Altitude,

at most one Node consists of **that** Latitude plus **that** Longitude plus **that** Altitude.

This association with Latitude, Longitude, Altitude **provides the preferred identification scheme for** NodeConsistsOfLatitudePlusLongitudePlusAltitude.

Node is an entity type.

Reference Scheme: Node has Node_ID.

Reference Mode: .ID.

Fact Types:

Node consists of Latitude plus Longitude plus Altitude.

Node has Node_ID.

Arc from Node to Node.

Polygon has Node in Sequence.

NodeType of Node.

Informal Description: *Node is a point, which may be the endpoint or intersection of a line or boundary.*

NodeType is a value type.

Portable data type: Text: Variable Length.

Fact Types:

NodeType of Node.

Informal Description: *How the node will be interpreted. Examples: Object or arc node.*

NodeType of Node.

For each Node, **at most one** NodeType of **that** Node.

It is possible that the same NodeType of **more than one** Node.

Polygon describes Layer.

Each Polygon describes **at most one** Layer.

It is possible that more than one Polygon describes **the same** Layer.

Polygon has Node in Sequence.

It is possible that more than one Polygon has **the same** Node in **the same** Sequence

and that the same Polygon has **more than one** Node in **the same** Sequence

and that the same Polygon has **the same** Node in **more than one** Sequence.

In each population of Polygon has Node in Sequence, **each** Polygon, Node, Sequence

combination occurs at most once.

This association with Polygon, Node, Sequence provides the preferred identification scheme for PolygonHasNodeInSequence.

Polygon is an entity type.

Reference Scheme: Polygon has Polygon_ID.

Reference Mode: .ID.

Fact Types:

GeoArea bounded by Polygon.

Polygon has Node in Sequence.

Polygon has Polygon_ID.

Arc bounded by left Polygon and right Polygon.

Polygon describes Layer.

Informal Description: *a figure, especially a closed plane figure, having three or more, usually straight, sides. Polygons are defined by arcs. To define a given polygon, trace around its area in a clockwise direction recording the component arcs and their orientations. If an arc has to be followed in its reverse orientation to make the tracing, it is assigned a negative sign in the database.*

Sequence is a value type.

Portable data type: Numeric: Unsigned Small Integer.

Fact Types:

Polygon has Node in Sequence.

E-R Diagram

Following is an Entity-Relationship (E-R) view of the model shown previously as text and ORM notation. E-R is not able to capture all of the constraints of ORM, but it captures the simple constraints that I have included.

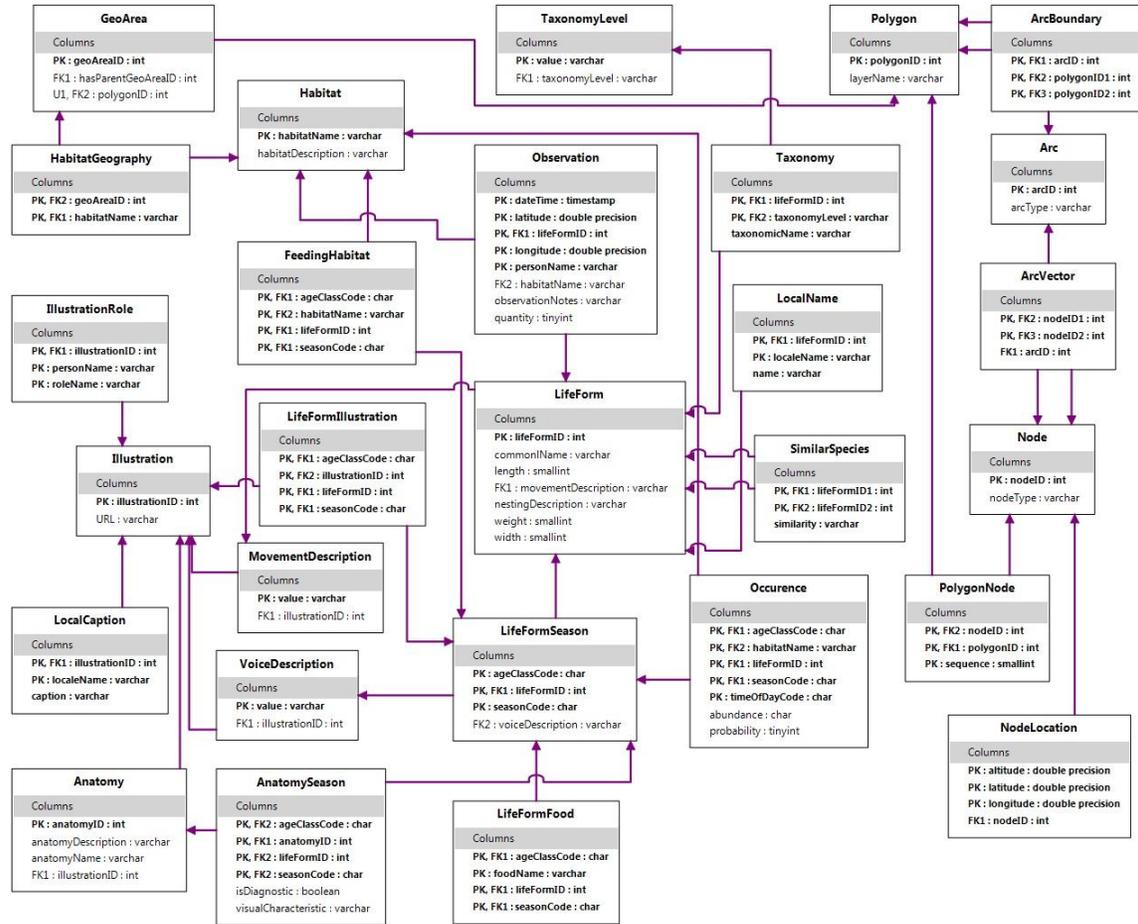


Figure 7 Entity-Relationship Model

Since this is only another view of the same model, all the text given previously applies here, too.