# Can Fossils be Used to Study What Modern Ecosystems Were Like Before They Were Impacted by Humans?


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Chapter 4
**Reconciling Scale in Paleontological and Neontological Data: Dimensions of Time, Space, and Taxonomy**


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**Abstract** Conserving biodiversity in the face of expanding human degradation of ecosystems is facilitated by understanding the natural state of communities prior to the impact of anthropogenic disruptions. Reconstructing communities and ecosystems as they existed in the past requires data from the fossil record on their species composition, richness, and abundance. Fossil data are potentially different from data collected from living communities in their spatial, temporal, and taxonomic scales and these differences must be understood so that accurate comparisons can be made between past and present states of living communities. Fifty-four long-term ecological studies of a wide range of taxon groups (mammals, invertebrates, plants, corals) and habitat types (marine, terrestrial, freshwater) were surveyed from the published ecological literature to determine the range of spatial, temporal and taxonomic scales at which data are commonly collected in ecological research. Long-term ecological studies encompass spatial scales from 50 $m^2$ to 100,000 $km^2$ and temporal scales from 5 to 100 years. Most studies resolve taxa to the species level and count individuals, although plant and coral studies sometimes quantify species by percent cover. All taxon groups and habitat types were studied across a wide range of spatial and temporal scales. Whether or not data from fossils can be collected and analysed at scales comparable to data from living communities depends on the type of organism, as well as the taphonomic circumstances of preservation, accumulation and deposition. Marine invertebrates can be sampled at comparable spatial and taxonomic scales to living invertebrates, but time averaging degrades the temporal resolution of the fossil deposits. Vertebrate fossils provide data at comparable taxonomic scales with some reduction in spatial and temporal resolution relative to live data. Plant fossils and pollen are capable of being sampled at temporal resolutions comparable to modern



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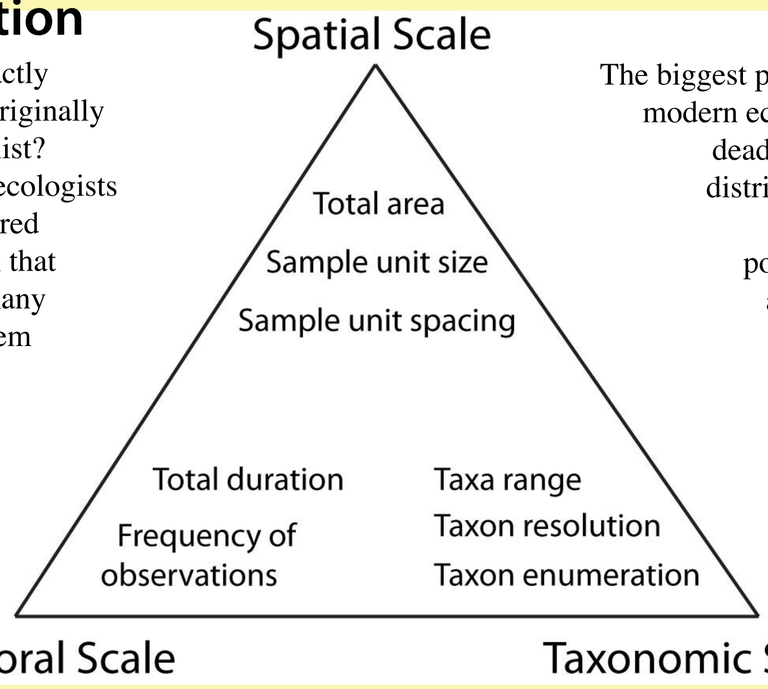
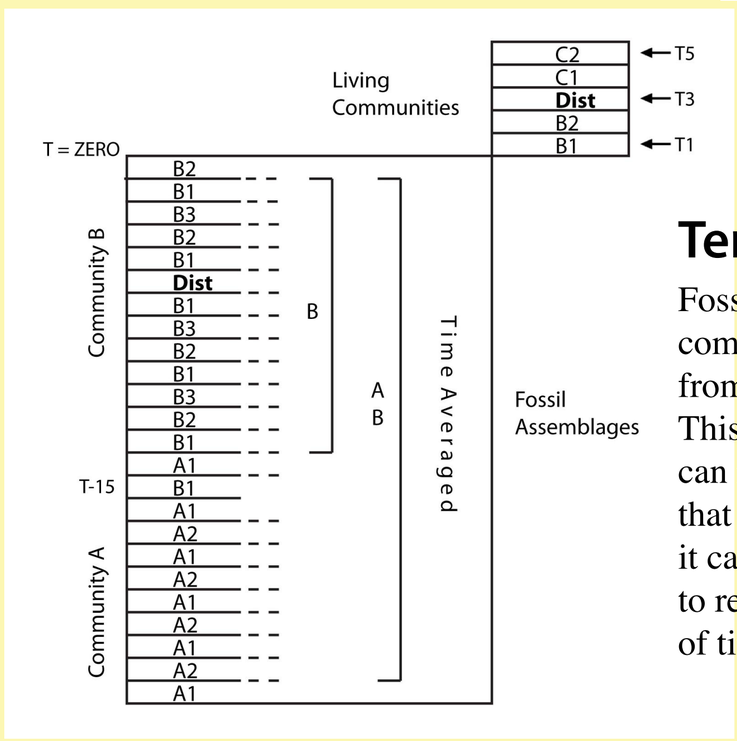
## The Challenge of Ecological Restoration

One of the challenges of ecological restoration is determining exactly what a restored ecosystem should look like. What species were originally part of the ecosystem and in what relative abundances did they exist? This is not easy to know because, in most cases, by the time that ecologists are able to census and study an ecosystem it has already been altered by human interference. There may be some historical information that can be used to understand the past state of an ecosystem, but in many cases humans have probably been causing changes to the ecosystem for hundreds, if not thousands, of years. What is needed are data on the diversity, composition, and relative abundances of species as they existed in the ecological community before significant human impact. Such data might be provided by the fossil record, but in order to be useful, the ecological information gleaned from fossils must be comparable to the information from the living community collected by ecologists.




## The Scale Problem

The biggest potential problem with using fossils to reconstruct a modern ecosystem as it existed in the past is that fossils (the dead remains of the former community) are not usually distributed through space and time in the same way that they were when they were living organisms. These potential differences between the living and the dead are all essentially differences in scale. Fossils may be collected at different spatial scales than the living community was censused and fossils from different times may be mixed together. Also, it may not be possible to identify the fossil organisms as precisely as the living ones. Ecological data collected at one set of scales may be misleading if compared to data collected at different scales.

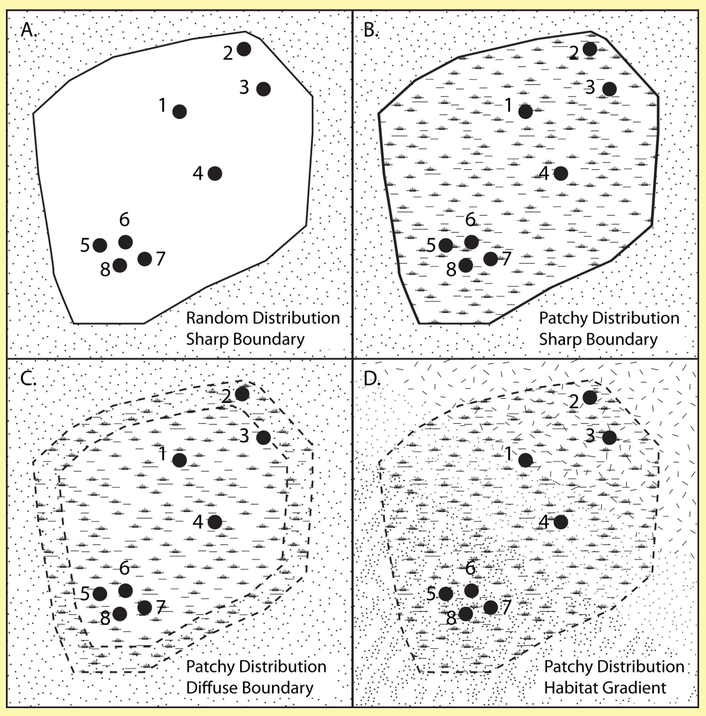



## Temporal Scale

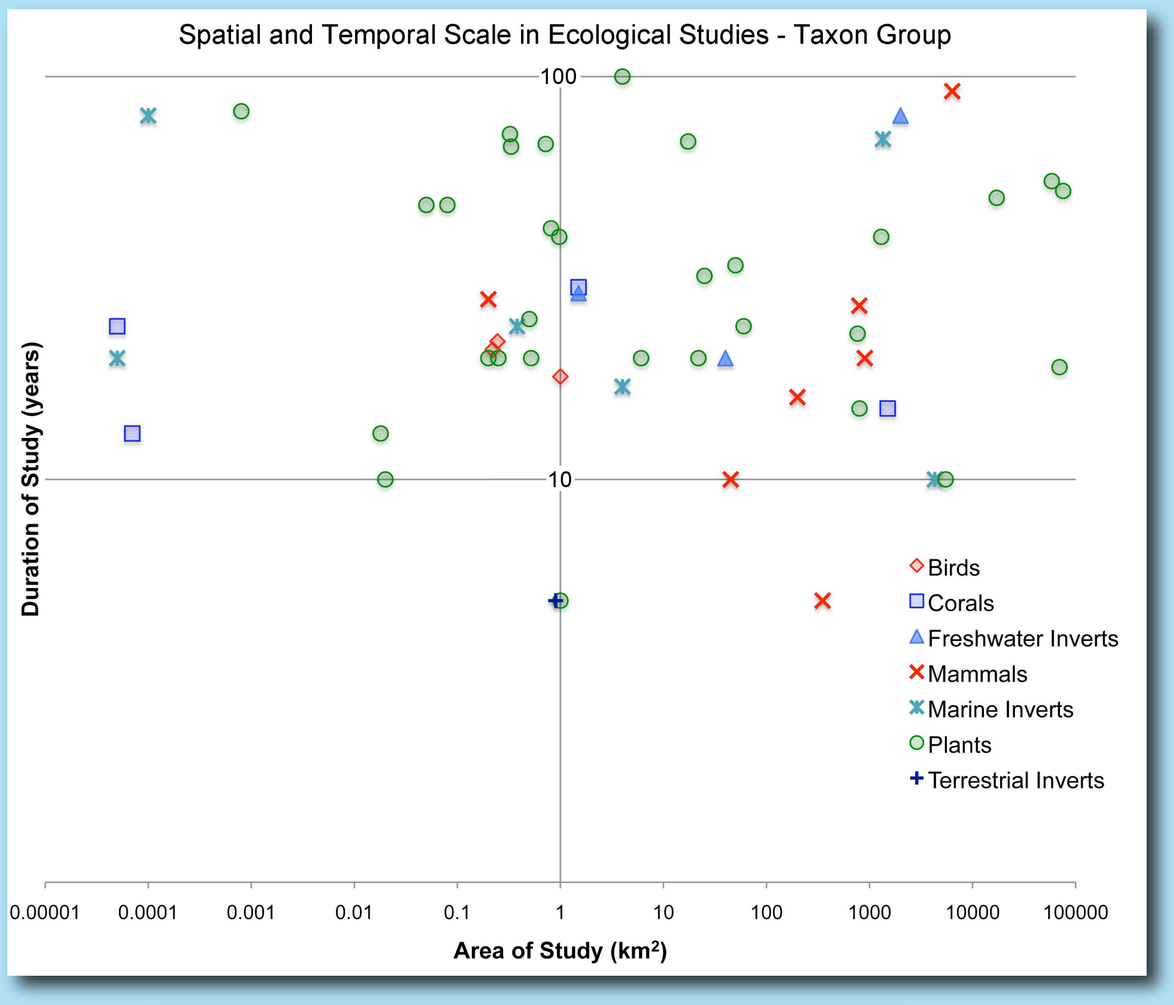
Fossilization tends to combine remains from different times. This time averaging can mix together species that didn't co-occur and it can make it impossible to resolve short intervals of time in the fossil record.

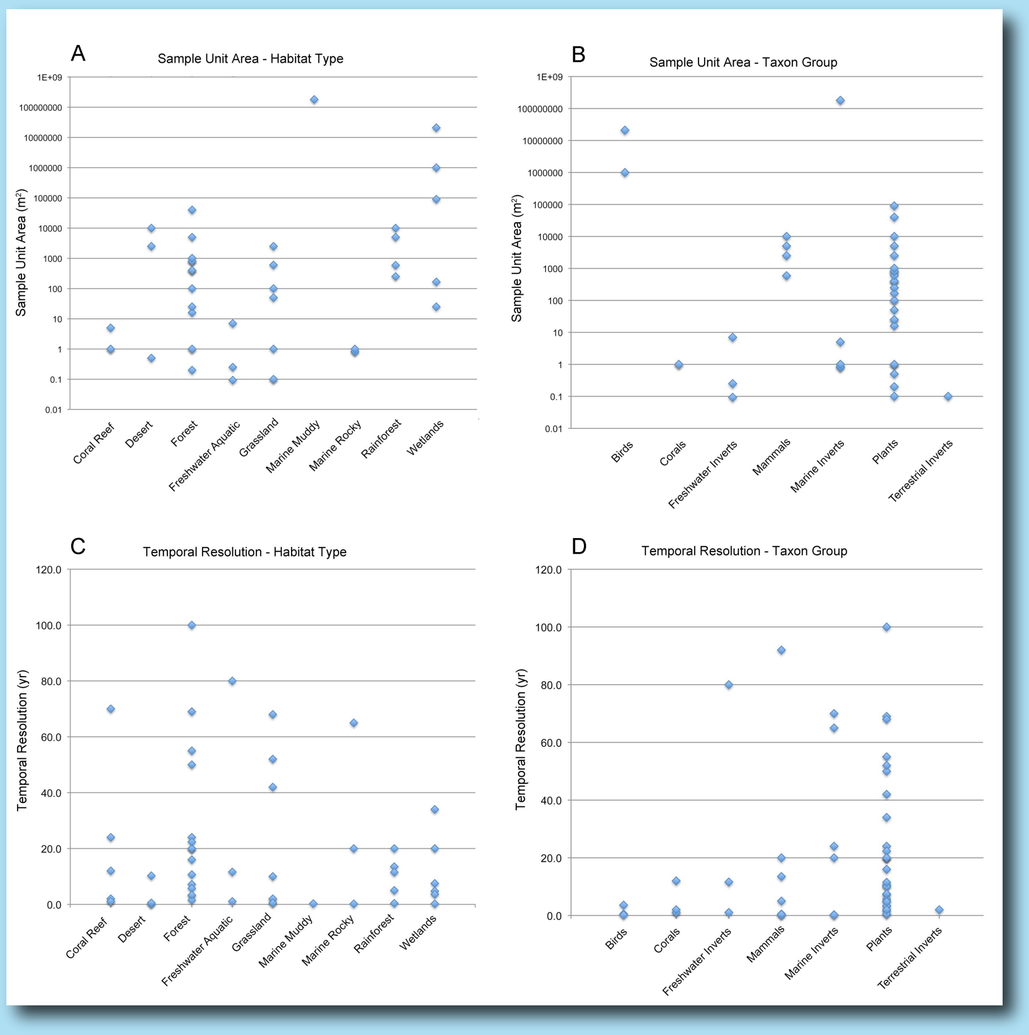
## Spatial Scale

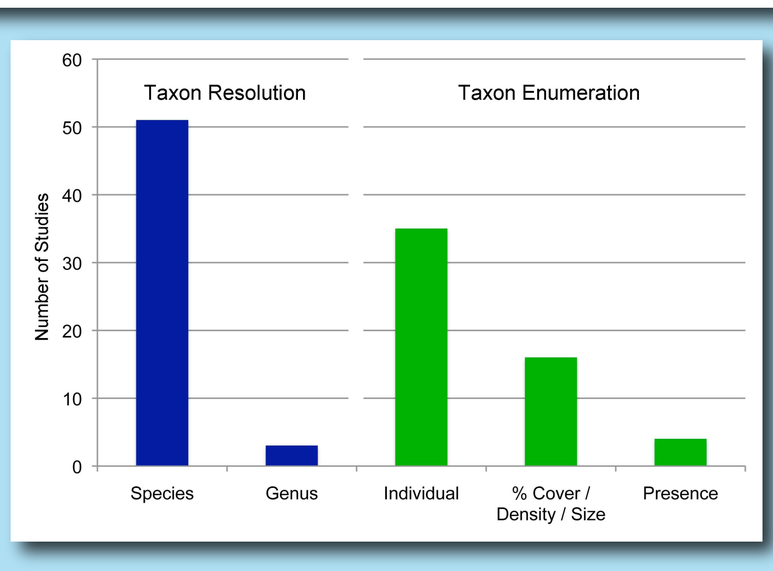
If habitats are patchy in their distribution of organisms or if there are environmental gradients, then how you space your observations can impact the types and numbers of species you observe.




# What are the Scales Inherent to Long Term Ecological Studies?




## What is the Potential for the Fossil Record to Match the Scales of Ecological Studies?

| Taxon \ SCALE | Spatial | Temporal | Taxonomic |
|---|---|---|---|
| (E)xcellent (M)oderate (P)oor | | | |
| Invertebrates | E | P | E |
| Vertebrates | M | E | E |
| Plants | P | E | P |