Rare Species

In general, a connotation where rare species are synonymous with legal protections exists in popular culture Kruckeberg & Rabinowitz (1985). However, rarity is the normal condition under which a vast multitude of species in all kingdoms of life exist, and only a subset of these species are at risk of extinction (Enquist et al. (2019), Flather & Sieg (2007)). Rare species are inherently organisms which are difficult to detect in nature relative to other 'common' species (Rabinowitz (1981)), but see Kondratyeva et al. (2019) for elaborations on rarity. One of the most consistently supported, both empirically and theoretically, observations in ecology is that the majority of species in any one location are represented by only a few individuals (Preston (1948), Stohlgren et al. (2005), Manzitto-Tripp et al. (2022)).

Rare species encode enormous amounts of functional diversity to an area and have been shown in multiple cases to imbue an ability to respond to disturbance (Isbell et al. (2011), Leitao et al. (2016), Mouillot et al. (2013), Oliver et al. (2015)). While we focus on large functional groups in SECTION XX, each of these groups has enormous variation within them, and due to the sheet number of rare species, they comprise most of the variation within these groups (Kondratyeva et al. (2019), Mouillot et al. (2013)). Rare species are also capable of reducing the possibility and severity of biological invasions (Lyons & Schwartz (2001), Oakley & Knox (2013)).

A popular conceptual framework to discuss these species may be considered which contains three dimensions, 1) the geographic expanse of the species, 2) their relative restriction to particular habitats, 3) and the number of individuals per population 'size' (Rabinowitz (1981)). Collectively the interaction between these traits results in a matrix with eight cells (Table 1), seven of these cells being rare species, six of which occur more frequently (Rabinowitz (1981)). The rare species which receive most of the attention, are those which are restricted to particular habitats across narrow geographical extents, *'narrow (local) endemics'* (Table 1 & 2) (Kruckeberg & Rabinowitz (1985)). In general narrow endemics tend to be the species which require special legal protection to ensure their habitats undergo minimal alterations. However, the remaining types of rarity still call for documentation by land management agencies.

Seven Forms of Rarity
From Rabinowitz 1981

Geo. Range: Habitat: Population Size	Large		Small	
	Wide	Narrow	Wide	Narrow
Large, dominant somewhere	Locally abundant over large range in several habitats	Locally abundant over large range in a specific habitat	Locally abundant in several habitats but restricted geographically	Locally abundant in a specific habitat but restricted geographically
Small, non-dominant	Constantly sparse over large range in several habitats	Consistently sparse in a specific habitat but over a large range	Constantly sparse and geographically restricted in several habitats	Constantly sparse and geographically restricted in a specific habitat

A typology of rare species based on three characteristics: geographic range, habitat specificity, and local population size. Note upper left box are common species

> *"Many species are abundant in portions of their range, but uncommon in others Brown et al. (1995), Ter Steege et al. (2016)"* — Enquist et al. 2021

Using the conceptual model in Figure 1 we see that a majority of species in the UFO field office which would be considered rare are likely to have 'Large' Geographic Ranges (left two columns, note the upper left most entry represents common species). These three cells of rare species are less likely to be have federal protections, although at the edges of their ranges may have state protections, as they fundamentally at lower risk of extinction (Figure 2). Biologically, these taxa may have interesting properties, relating to their relative positions in the range of the species distribution. In particular, they may be species which are at the *edges* of their ranges. These species may be interesting as ones which are at the *trailing* edge ... and ones which are at the *leading* edge ... Conserving *leading* edge populations at the local level is important as they may contain many forms of genes which are pre-disposed to adapting to climate change associated variables.

As the land which the UFO administers represents only a subset of the range of variation which exists in Western Colorado. An obvious example is that we lack both alpine, and many types of forests. Accordingly, species which may be common on Forest Service Land, may be rare on UFO land. Naturally these species are not of concern for identifying lands which need enhanced protections as would be offered under regulatory protocols, but they provide opportunities for distributing reproductive material to adjacent sites.

However, it is possible that land management has allowed for them to decline in our study area. We can identify these taxa using ... We can consider that their range of habitat specificity (Rabinowitz (1981)) may include a subordinate element, tolerance fo disturbance, which includes many human enacted actions. *DISCUSS THIS IS WHAT WE WILL FIND USING NOVEL INDEX OF RARITY* Recently approaches to develop a consensus index of Rabinowitzs sense of rarity exist (Maciel & Arlé (2020), Maciel (2021))...

The other half of the table represents species which are very well tracked by multiple tiers of government..

Seven Forms of Rarity
From Rabinowitz 1981 - Species modified to Field Office

Geo. Range: Habitat: Population Size	Large: Wide	Large: Narrow	Small: Wide	Small: Narrow
Large, dominant somewhere	Common	Camissonia eastwoodiae	Sclerocactus glaucus	Penstemon retorsus
Small, non-dominant	Draba oligosperma	Cypripedium calceolus ssp. parviflorum		Eriogonum pelinophilum

A typology of rare species based on three characteristics: geographic range, habitat specificity, and local population size.

Under the conceptual model in Figure 1 species with 'Small' Geographic Ranges and 'Wide' Habitat Specificity (column 3) would be expected to be encountered at numerous AIM plots. These taxa are almost always generally noted as rare by the State, and BLM, and may be considered threatened or endangered by the United States Fish and Wildlife Service (USFWS), the agency which administers the *Endangered Species Act* (Figure 2).

Finally the column at right represents the species at the fundamental core of our notions of 'rarity'. These taxa are generally warranted legal protections as human modification of their habitats...

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