Hunting behavior of the extinct dire wolf (*Canis dirus*): An injury analysis using geospatial technologies

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BACKGROUND

Two wolf species coexisted in the late Pleistocene:

Grey wolf (*Canis lupus*): 50-130 lb	**Dire wolf** (*Canis dirus*): 125-175 lb
• Survived Pleistocene extinctions • Skeletal pathologies are not curated and low in number	• Rapid extinction at the end of Pleistocene • High number of skeletal pathologies are curated at the La Brea Tar Pits

Extinct & extant wolves skeletal patterns

Compared to grey wolves, dire wolves:

- Had much larger skull, robust scapula, and limb bones.
- Had greater muscle mass in the limbs.
- Took large megafaunal prey (Fig. 2).

Previous research suggests that:

- Dire wolves share morphological features favoring **stability** with grey wolf subspecies that take larger prey**.**
- Hunting **locomotor performance may be hindered** by large size.[3]
- In canines, **strength comes at the expense of speed**.[2]

Extinction theories suggests that large Pleistocene carnivores **failed to adjust to the smaller and quicker prey** remaining after the mega-herbivore extinctions.[1] **This may explain why grey wolves survived the extinction event while the larger-bodied dire wolves did not.**

METHODS

This project is the first to spatially analyze hunting injuries using the GIS processing program **ArcMap**. Here we visualize the distribution of injuries on bones by "**mapping**" injured areas on a skeletal "**basemap**" with the following process:

- Record pathologies of extinct predators of the Pleistocene La Brea Tar Pits of Los Angeles (pit 61/67)
- Hand-draw or place pathologies and injuries over skeleton base map in ArcGIS
- Create heatmaps from spatial density of injuries

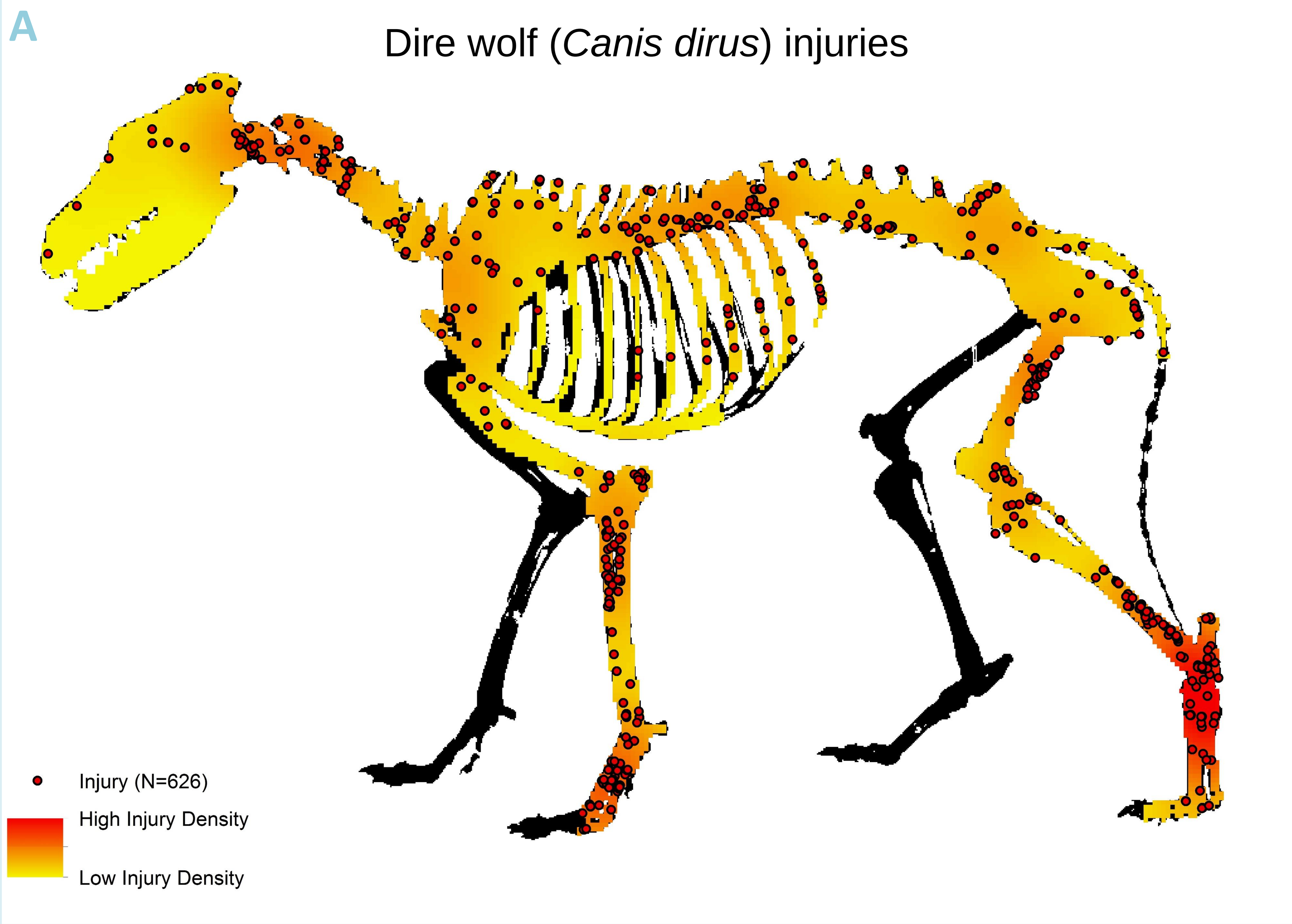
We defined the pathologies as follows:

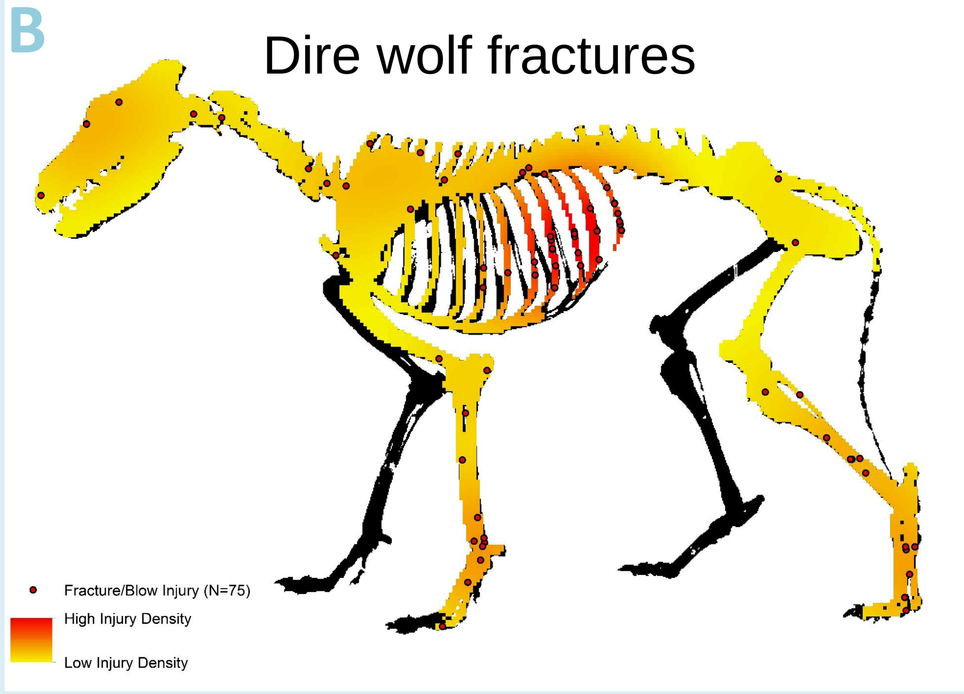
Musculoskeletal	Fracture
Reactive bone growths from abnormal muscle forces or ligament damage	*Impact injuries, bone fractures*

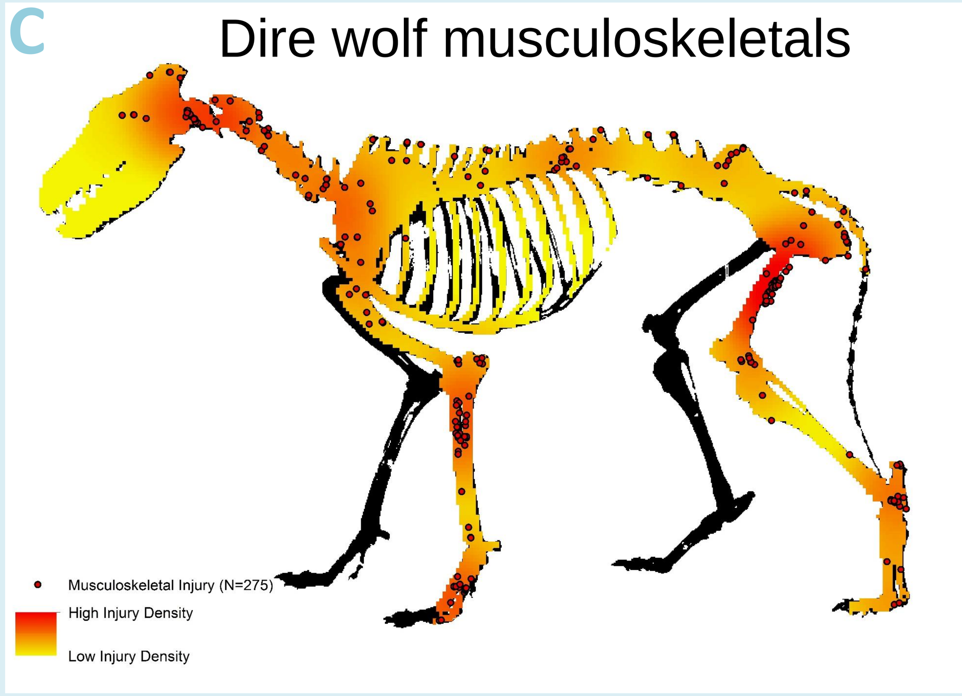
These injury hotspots can be interpreted as regions that were subjected to **excessive stresses** and **strains** more often than other less frequently damaged parts of the skeleton.

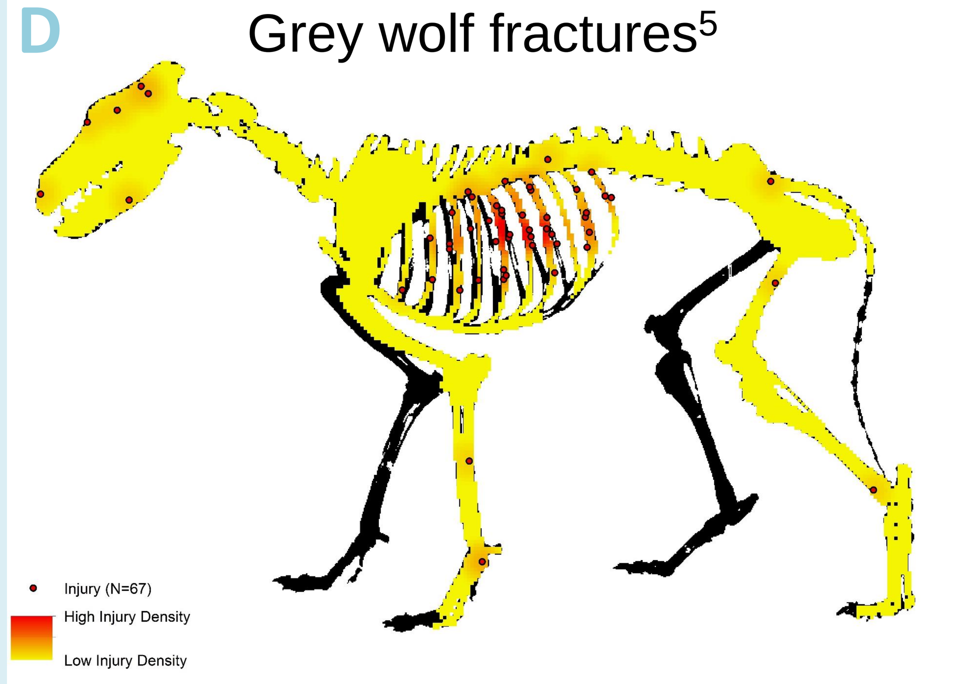
What do injury locations tell us about the hunting behavior of Pleistocene dire wolves?

RESULTS









Grey wolves' injuries (D) are most frequently **bone fractures** occurring in the **ribs**. These are typically inflicted by prey.

Dire wolf bone fractures (B) have a similar distribution.

Most dire wolf injuries were associated with **muscle strain** (C), creating the hotspots observed in the combined injury map (A).

CONCLUSIONS

Most dire wolf injuries were associated with muscle strain

Muscle strains are present in Pleistocene dire wolves but **not** in modern grey wolves possibly because:

- Dire wolves faced more extreme forces because of their larger prey (Fig. 2).
- However, it is impossible to be sure because there are no studies of muscles strain injuries in wolves.

Injury patterns in the dire wolf are consistent with a pursuit predator lifestyle

Given what we know about wolf prey, these **injury patterns** and **skeletal proportions** suggest that:

- Muscular injuries were caused by pursuit and bringing down relatively large prey (Fig. 2).
- Dire wolf neck and ankle joints were stressed and often and subjected to high loads during hunts.
- To take larger prey, dire wolves faced selection pressure to maintain strength and stability (not to fully maximize speed)**.**

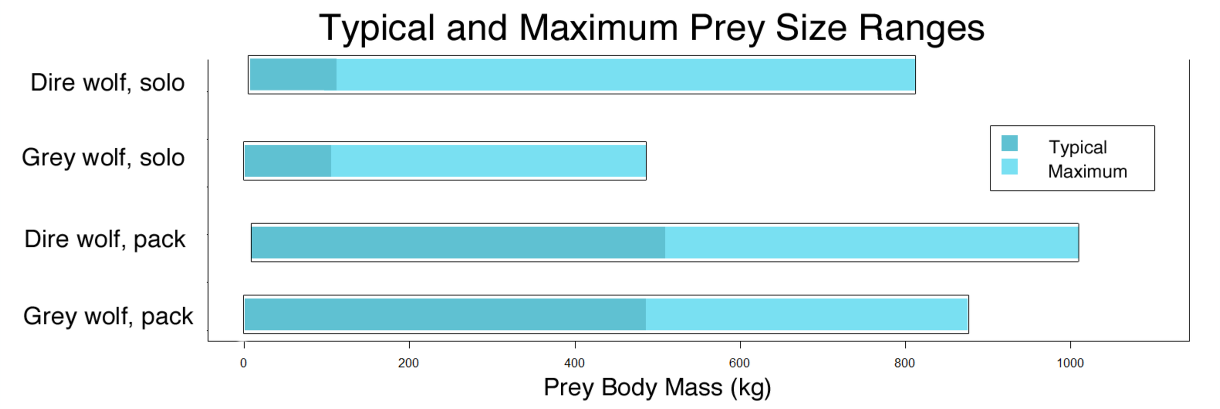


Figure 2: Typical and maximum prey sizes of lone and pack hunting wolves

BROADER IMPACTS

This project illustrates for the first time the usefulness of applying GIS technologies to non-georeferenced data, such as injury or disease distribution patterns on different species.

Our findings are important for conservation management and wolf reintroduction programs:

- It is important **consider the relative size of prey**
- Previous research suggests that wolves can adjust to larger prey (e.g. from elk to bison[4]), but perhaps wolves **may not be able to adjust to smaller prey**

ACKNOWLEDGEMENTS

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