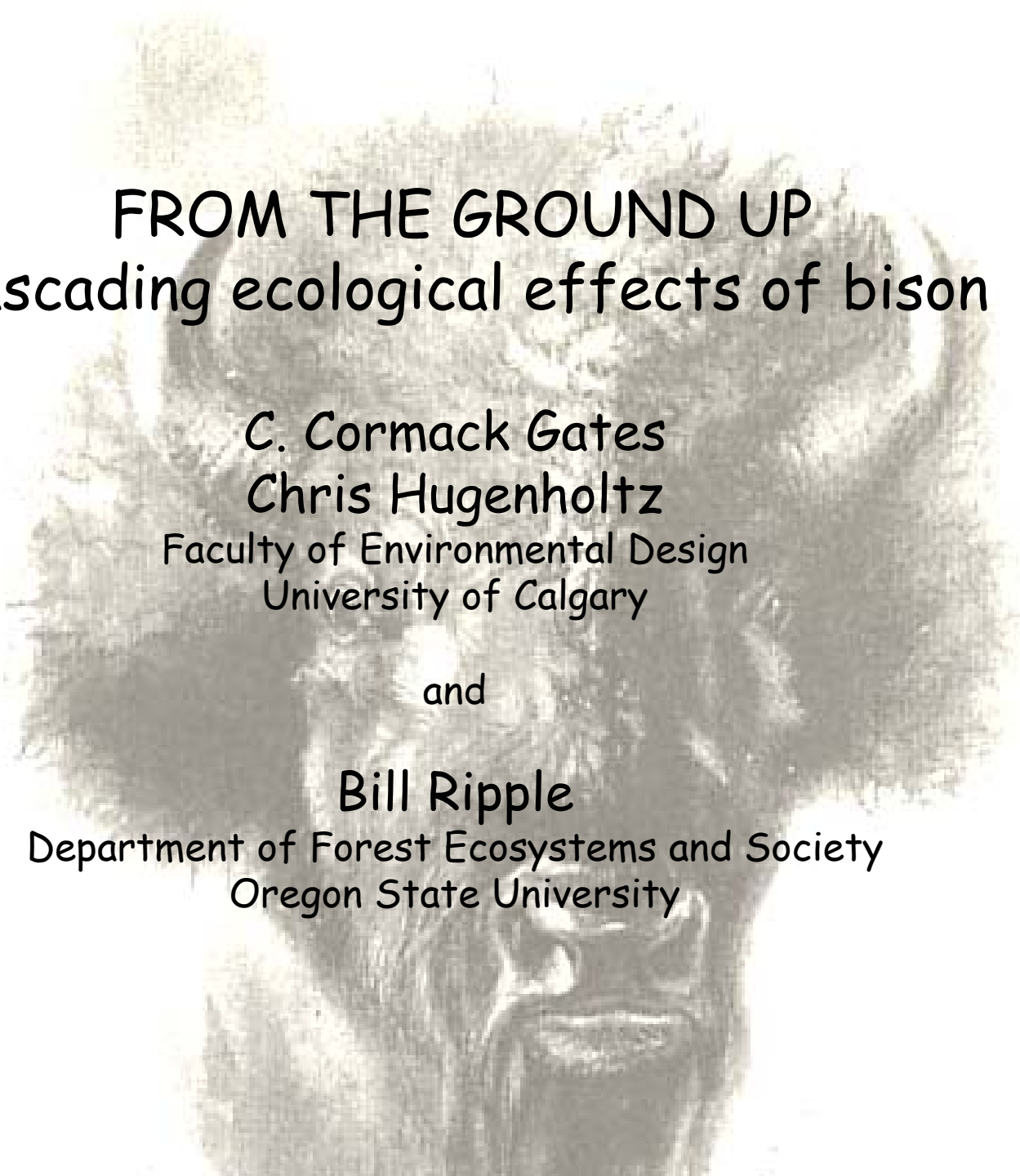
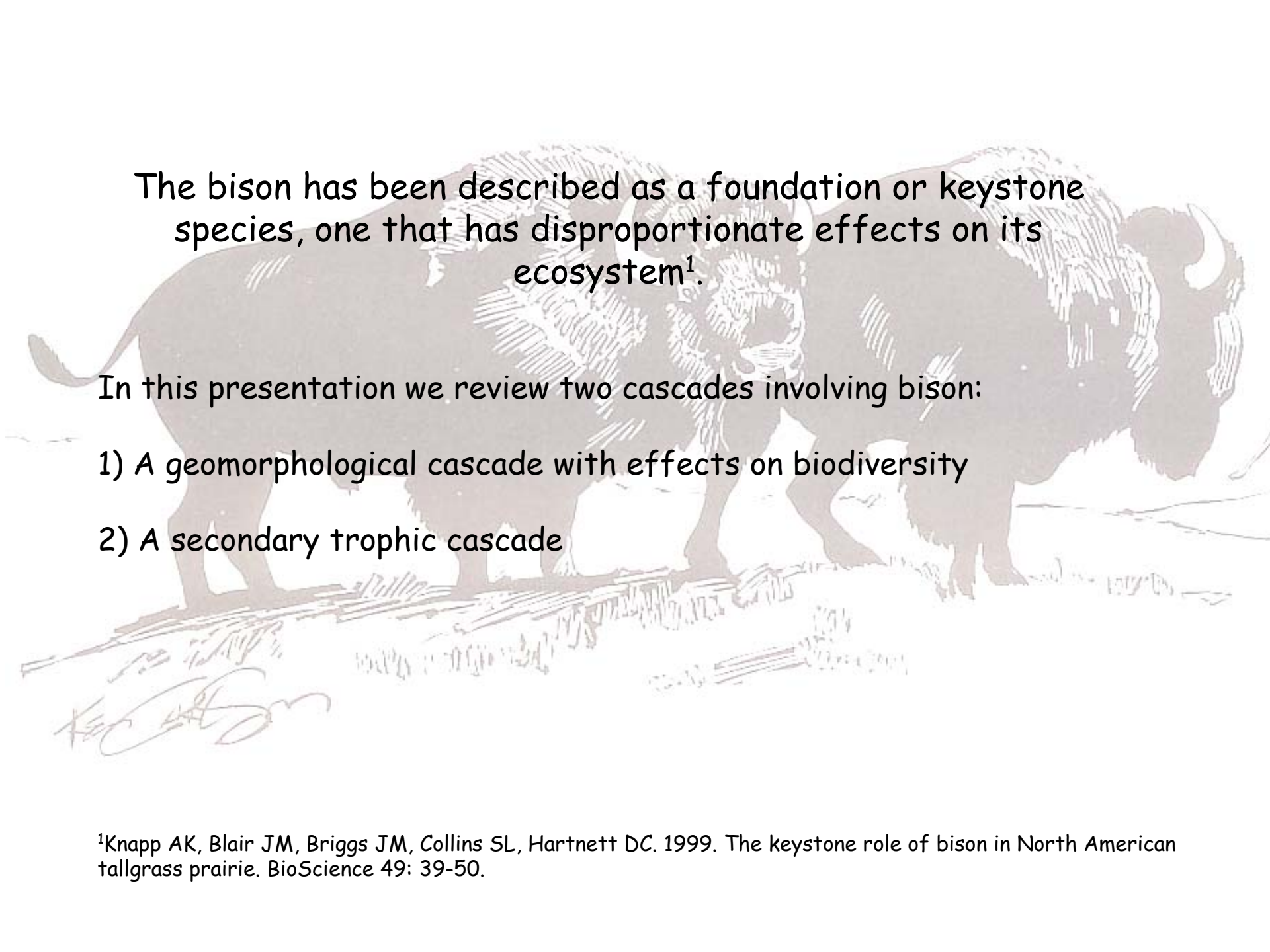


FROM THE GROUND UP
Cascading ecological effects of bison

C. Cormack Gates
Chris Hugenholtz
Faculty of Environmental Design
University of Calgary

and

Bill Ripple
Department of Forest Ecosystems and Society
Oregon State University



The bison has been described as a foundation or keystone species, one that has disproportionate effects on its ecosystem[1].

In this presentation we review two cascades involving bison:

1) A geomorphological cascade with effects on biodiversity

2) A secondary trophic cascade

[1]Knapp AK, Blair JM, Briggs JM, Collins SL, Hartnett DC. 1999. The keystone role of bison in North American tallgrass prairie. BioScience 49: 39-50.

Analogous to a cascading waterfall,

a cascade effect is a sequence of events in which

each event

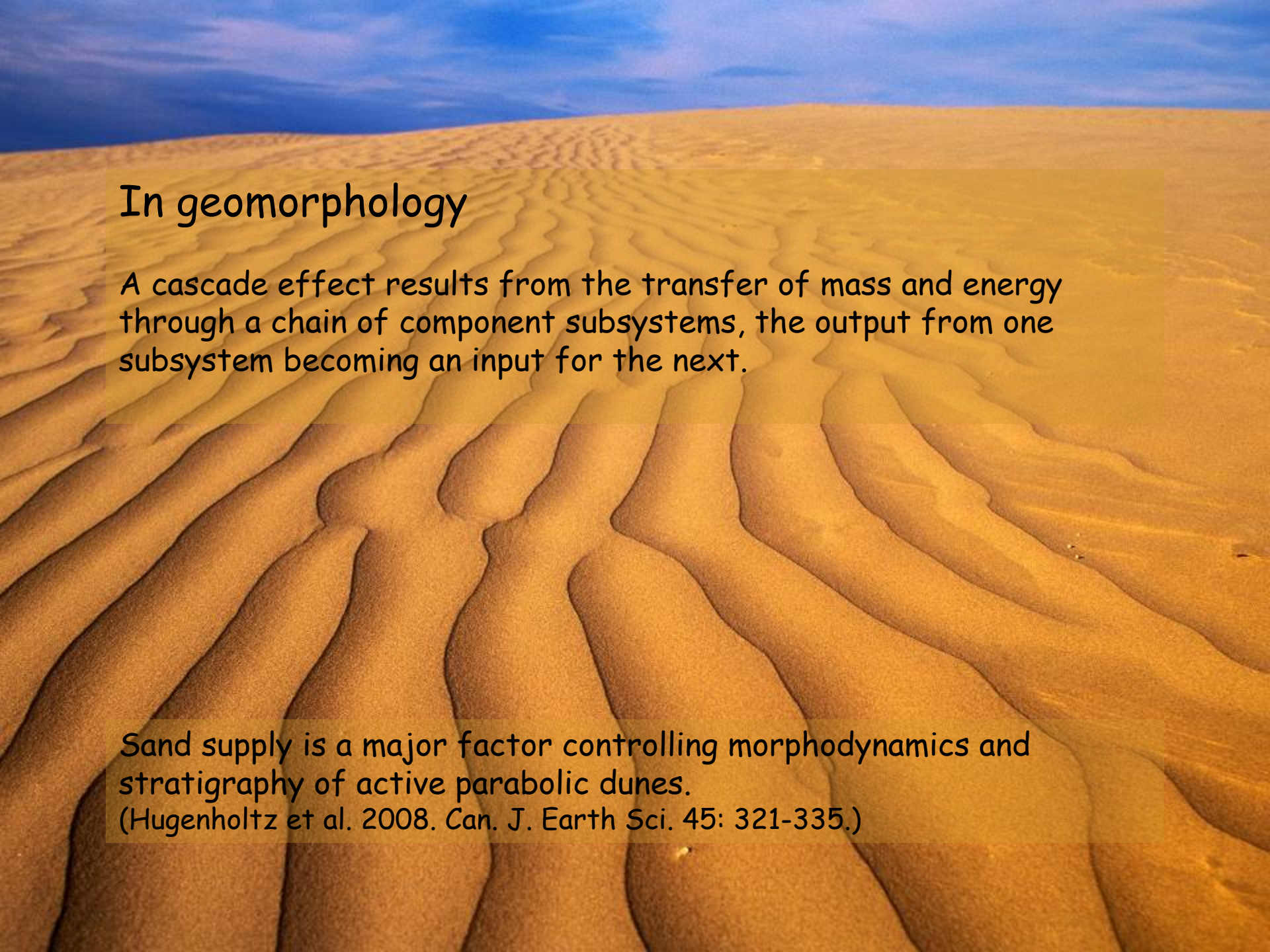
produces the

circumstances

necessary for

initiation

of the next.



In geomorphology

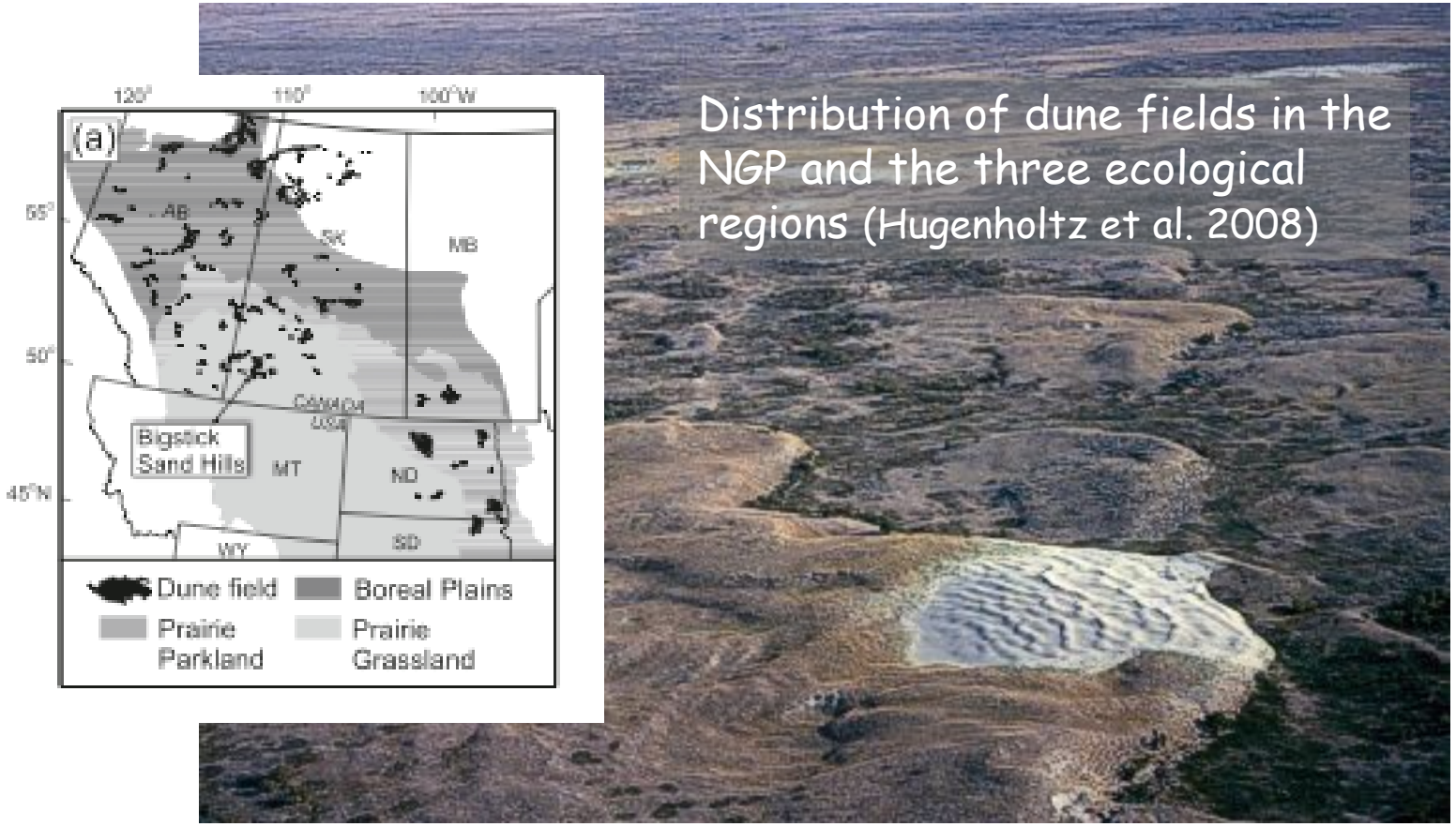
A cascade effect results from the transfer of mass and energy through a chain of component subsystems, the output from one subsystem becoming an input for the next.

Sand supply is a major factor controlling morphodynamics and stratigraphy of active parabolic dunes.
(Hugenholtz et al. 2008. *Can. J. Earth Sci.* 45: 321-335.)

Great Sand Dunes, San Luis Valley, CO

Aeolian landforms are surface features produced by either the erosive or constructive action of wind.

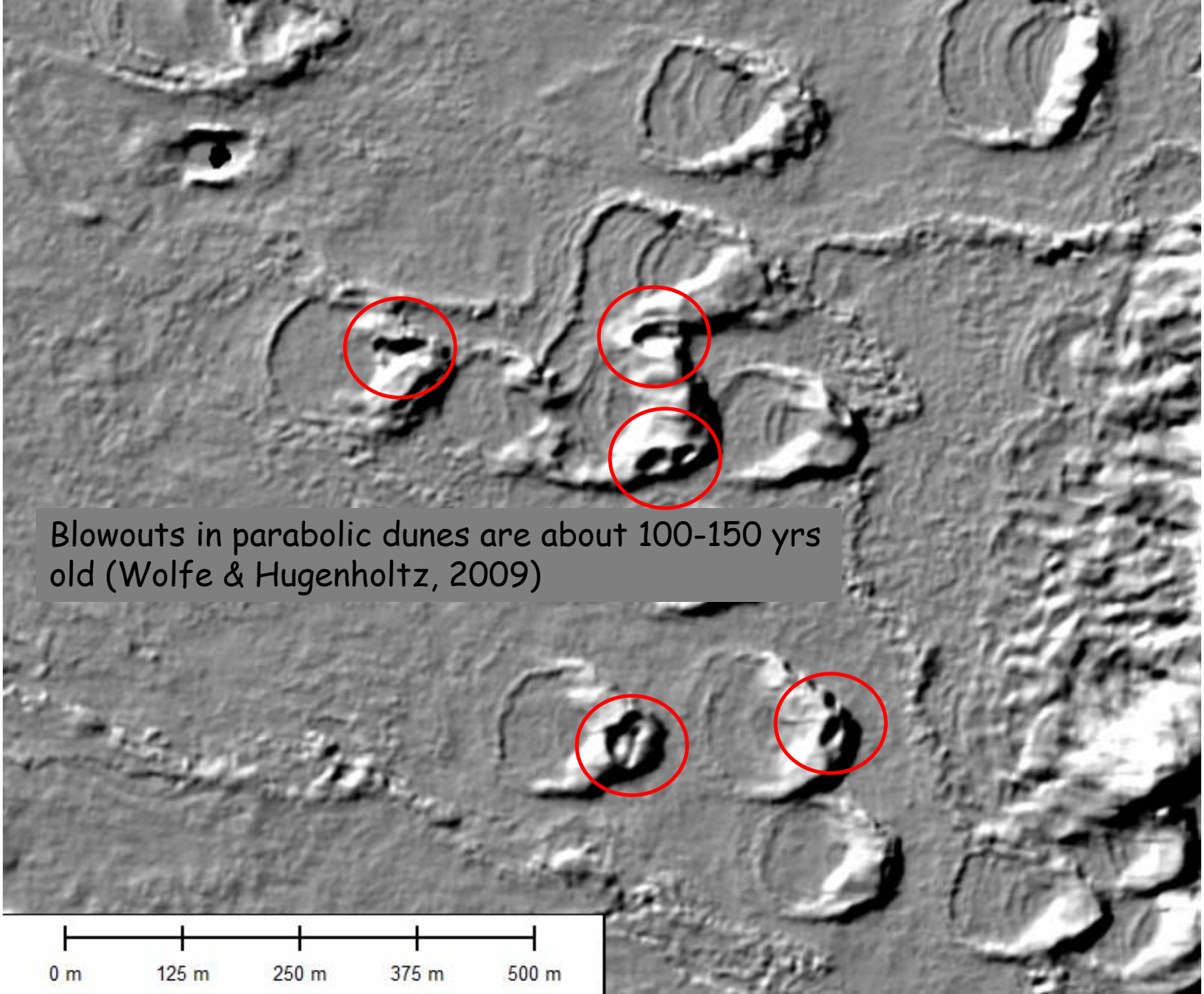
The word derives from Aeolus, the Greek god of the winds.



Distribution of dune fields in the NGP and the three ecological regions (Hugenholtz et al. 2008)

In the Canadian prairies, 50 sand dune fields occupy over 9000 km^2

Active dunes result from the presence of suitable sandy deposits left by glaciers, frequent occurrence of dry westerly winds, and sparse vegetation cover


Blowouts in parabolic dunes are about 100-150 yrs old (Wolfe & Hugenholtz, 2009)
0 m
125 m
250 m
375 m
500 m

Instrumentation used to measure wind speed through a blowout hollow

Wind speed slows upon entering, then accelerates at the centre and is further accelerated at the downwind exit.

Once formed, blowouts increase in size due to airflow acceleration (Hugenholtz & Wolfe, 2009


Blowouts can start small and become large

Most of Canada's dune areas are stabilized by vegetation; relatively few are active

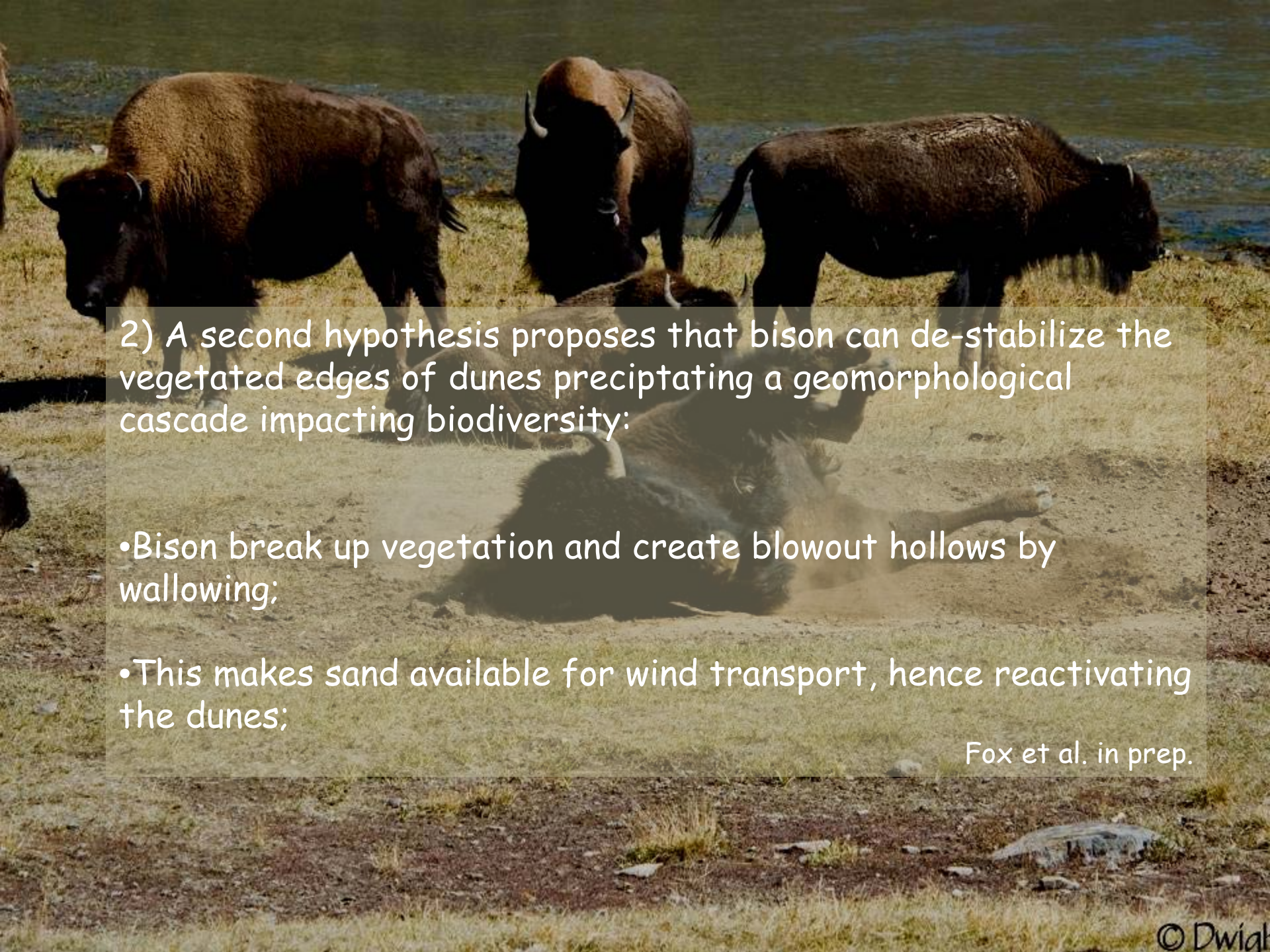
Most dunes stabilized during the past 150 years

1) One hypothesis attributes stabilization to cool moist periods promoting the development of vegetation cover that protects the dunes from wind erosion

Then when warm dry periods occur again, vegetation becomes sparse, dunes became active.

10 such periods have occurred in the last 5,000 years.

David, P.P., 1998. Eolian processes and landforms. Geological Survey of Canada. Bulletin, vol. 521, pp. 25 – 39.



2) A second hypothesis proposes that bison can de-stabilize the vegetated edges of dunes preciptating a geomorphological cascade impacting biodiversity:

•Bison break up vegetation and create blowout hollows by wallowing;

•This makes sand available for wind transport, hence reactivating the dunes;

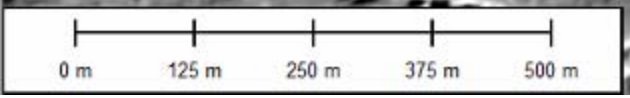
Fox et al. in prep.

Hillshade image derived from high-resolution LiDAR DEM

Blowout hollows are highly concentrated at the edges of sand hills (the Great Sand Hills, Saskatchewan).

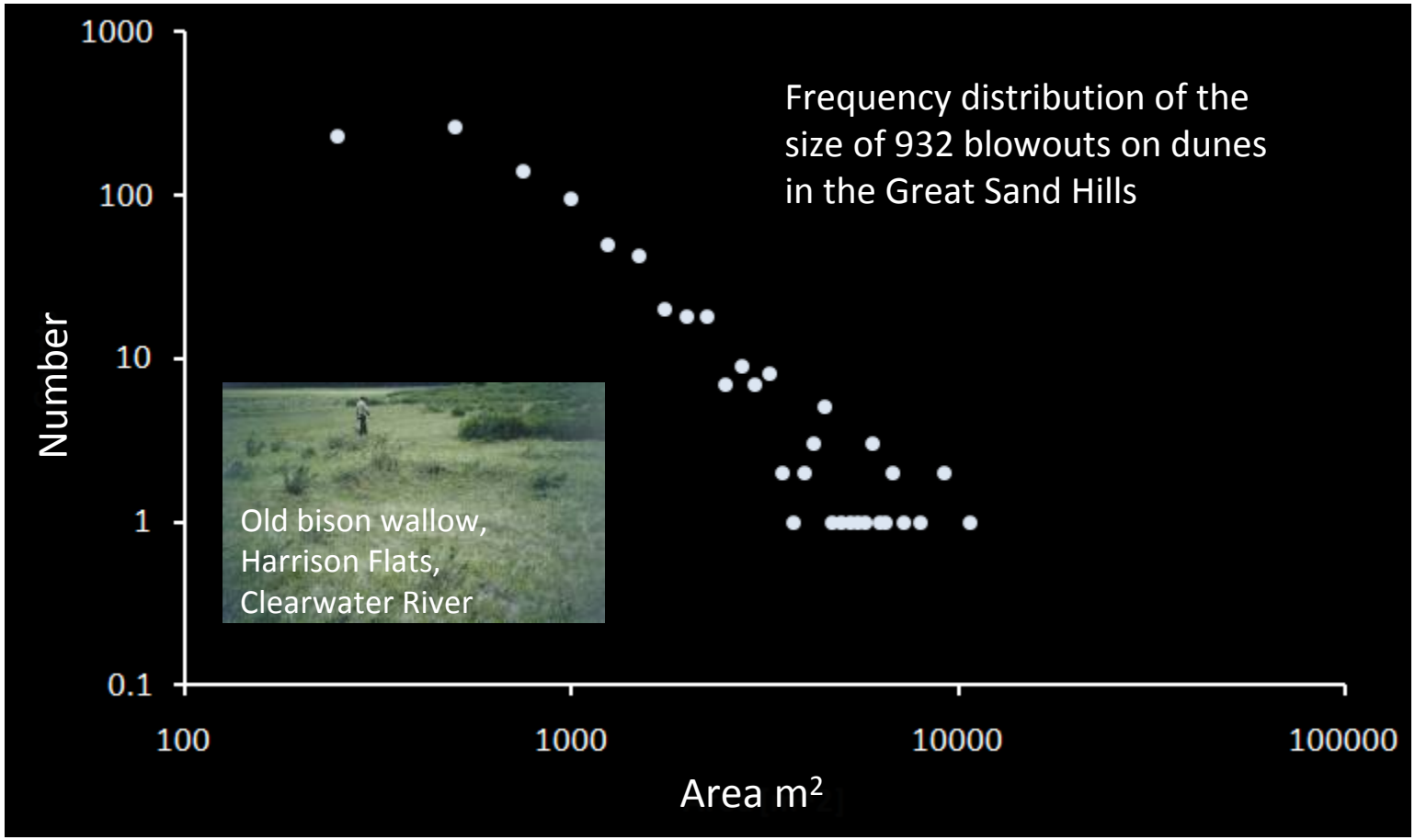
Bison were eliminated from the prairies about the time revegetation of the sand hills started.

Aerial view of wallow-pitted landscape in the Mackenzie Bison Range, NWT



Most stabilized blowouts in the Great Sand Hills are small (< 500 $m^{2)}$ and shallow (< 1.5 m).

They are about the size of large bison wallows.



Implications for biodiversity conservation and ecological restoration

Rare Sand Hills-Associated Species

Vertebrates
Ord's kangaroo rat
Plains hognose snake

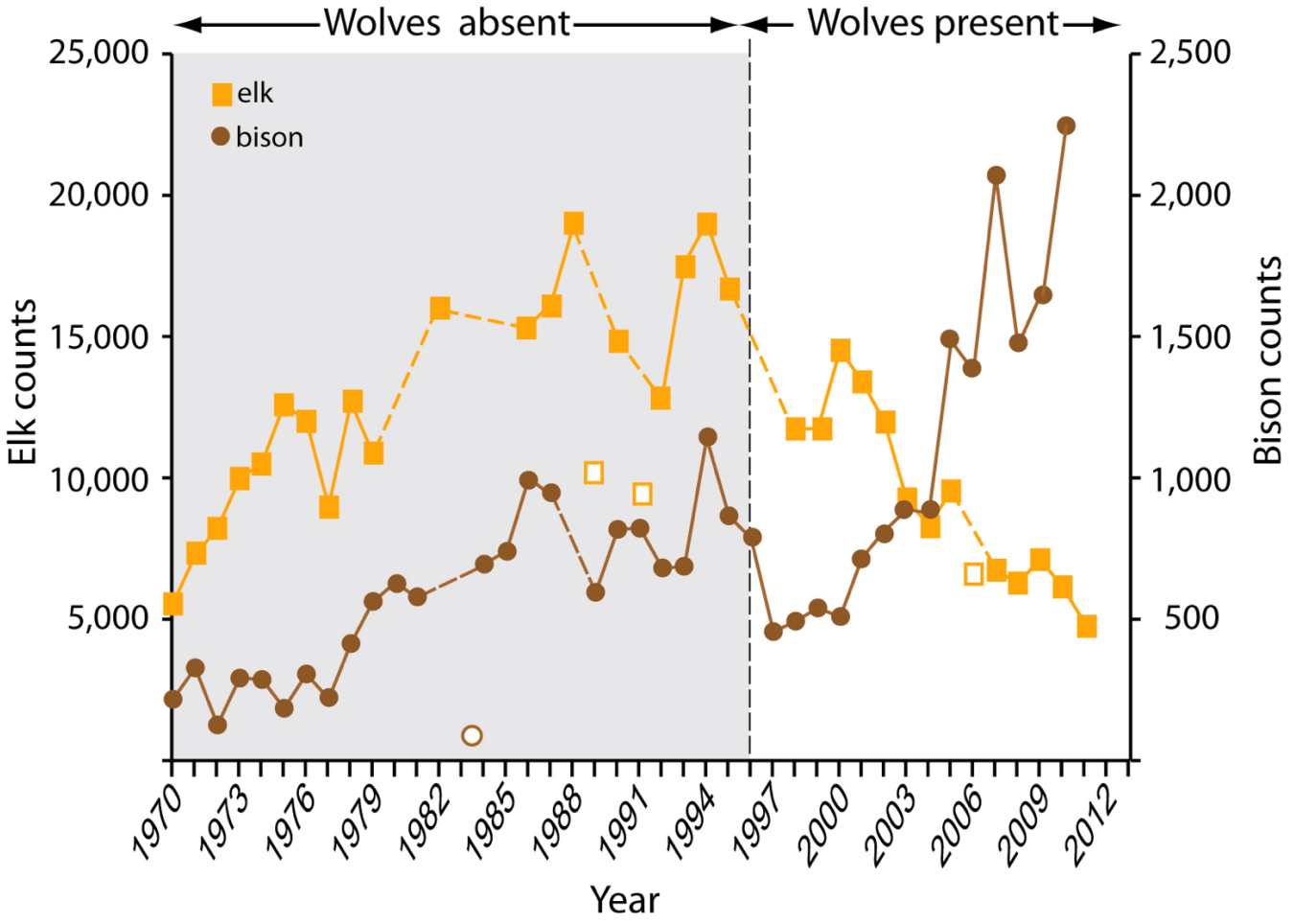
Invertebrates
Pale Yellow Dune Moth

Plants
Smooth arid goosefoot
Western spiderwort
Slender mouse-ear-cress
Tiny Cryptanthe
Small flowered sand-verbena
Carolina whitlow-wort,
Clamyweed
Skeletonweed

In ecology

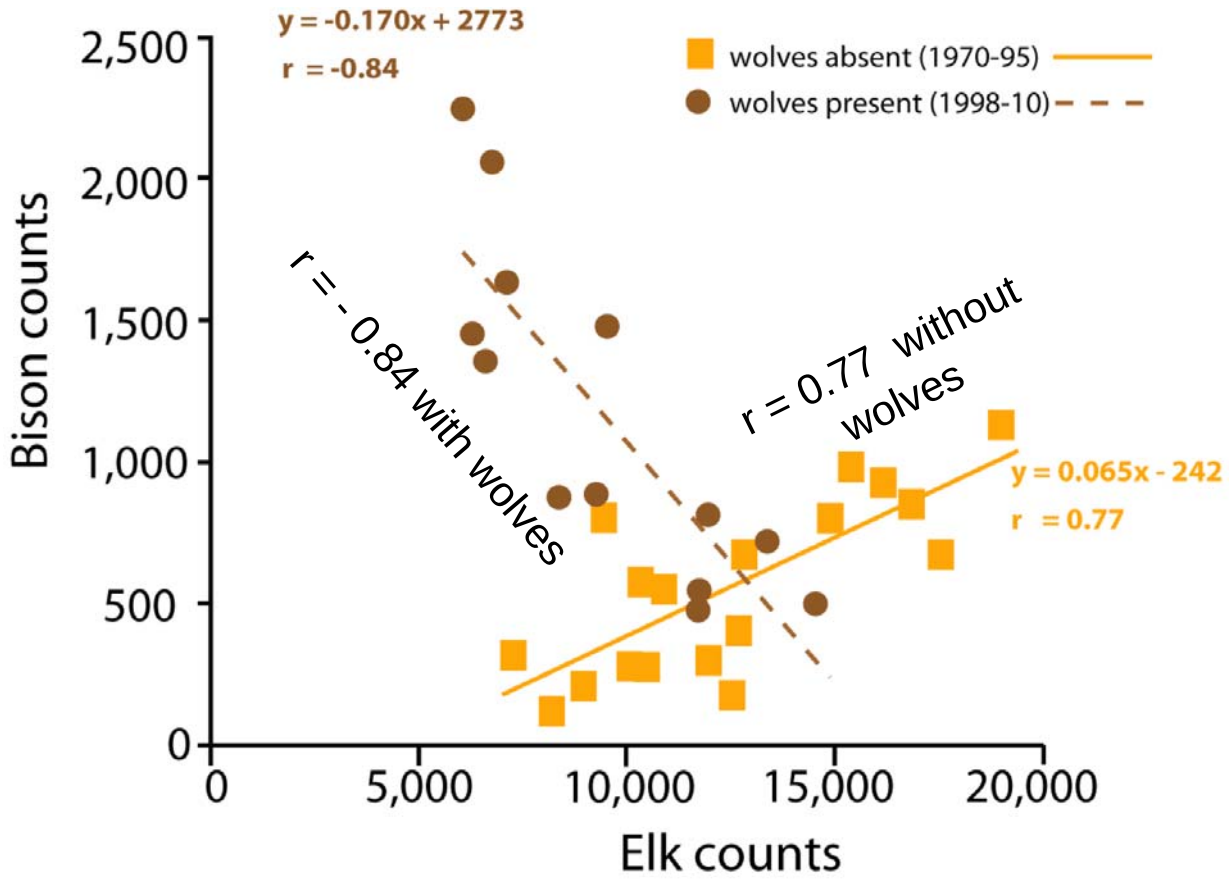
A trophic cascade occurs when a top predator substantially affects consumer (herbivore) behavior or population size, thereby influencing producer (plant) abundance, structure, or spatial distribution ..... and other species

Wolves/elk/vegetation/habitat



Yellowstone: Northern range elk and bison population trends.

Ripple, W., L. Painter, R. Beschta and C. Gates. 2011. Wolves, elk, bison, and secondary trophic cascades in Yellowstone National Park. Open Ecology Journal (in press).



The relationship between bison and elk abundance changed on the northern range after wolves were reintroduced.

Wolves absent: as elk increase, bison increase
Wolves present: as elk decrease, bison increase

(a)

(b)

(c)

(d)

Photographs showing (a) summer bison browsing, (b) winter bison browsing, (c) hedged Bebb willows, likely from bison browsing, and (d) an eroding streambank in the Lamar Valley.

Sources: W.J. Ripple—Figure 3a, 3c, 3d; Yellowstone National Park—Figure 3b.

CASCADES

Secondary Trophic Cascade:

An alternative top-down pathway by which predators can influence multiple trophic levels through mediating the competitive interaction between two prey species.

Predation reduces elk

Primary cascade

Forage release, bison increase

Herbivory affects woody plants

Secondary cascade

Secondary trophic cascade

Top down

CASCADES



Sand dunes activated

Wind scours then redeposits sand

Wallowing exposes sand

Geomorphological cascade

Ground up

Secondary trophic cascade

Top down

Predation reduces elk

Primary cascade

Forage release, bison increase

Herbivory affects woody plants

Secondary cascade