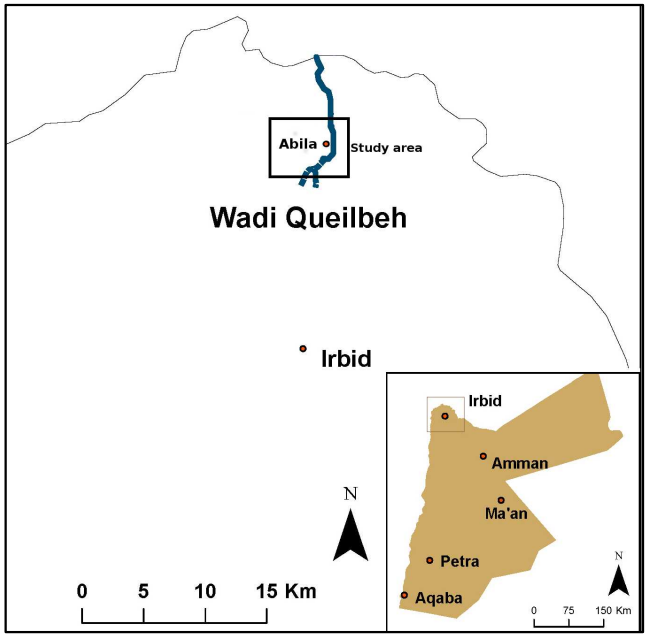
Questioning models of land degradation in arid and semi-arid regions: a re-assessment based on evidence from northern Jordan

Bernhard Lucke, FAU Erlangen-Nuremberg, Institute of Geography, Germany

Degradation at *Abila of the Decapolis* (northern Jordan)



Devastating man-made erosion
due to Muslim conquest & over-grazing postulated (typical example)

Flat tableland of horizontal limestone plateaus (old land surfaces?) dissected by valleys

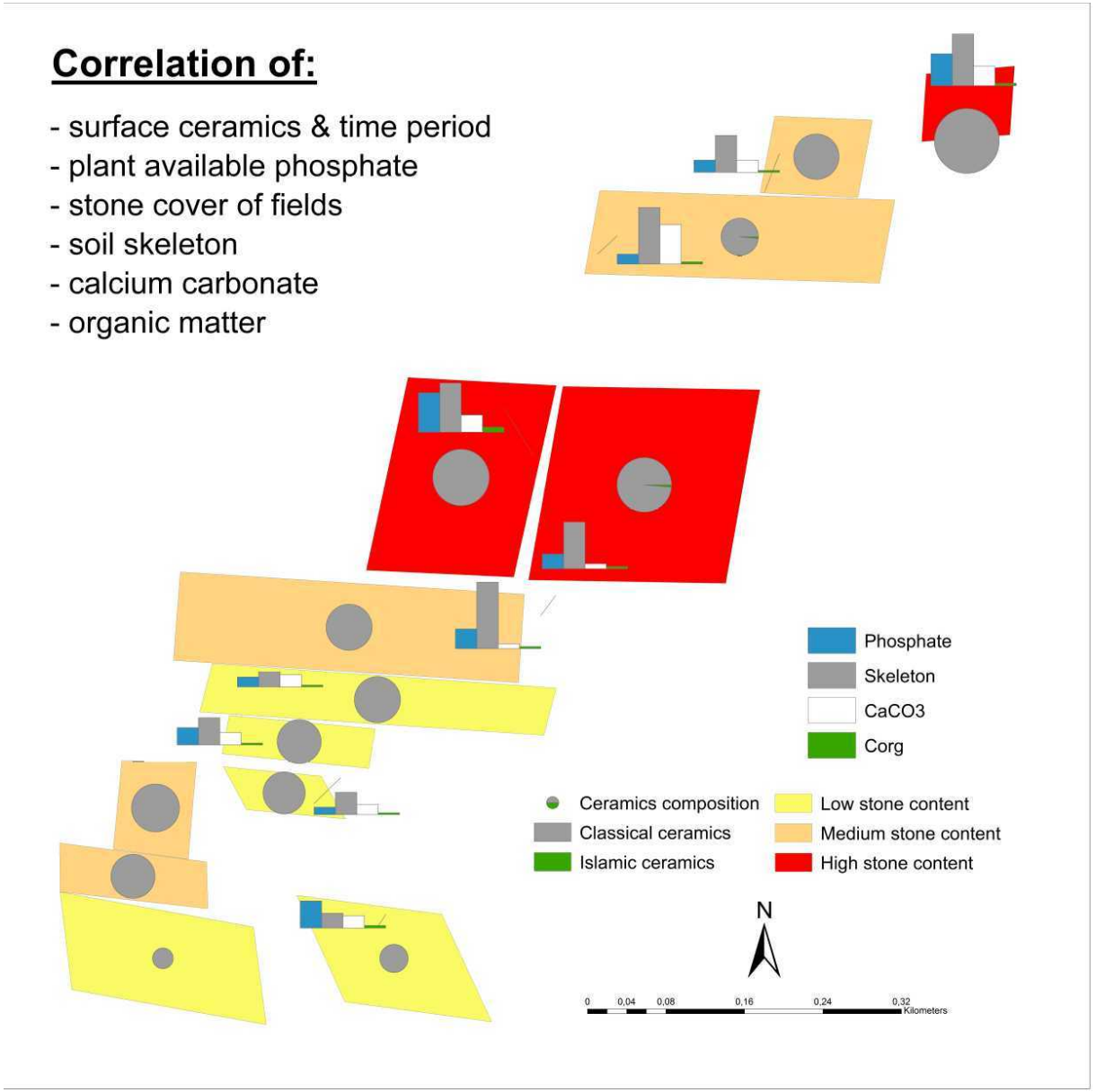
However, continuous soil cover on plateaus present, today intensely used for agriculture – past use unknown

- *We did intensive off-site survey of archaeological material on fields to reconstruct past land use intensity*
- *Associated plateau soils & sediments in valleys studied*

Results: plateau soils are old: **paleogullies buried > 9000 years ago** (Lucke, 2008, 2017)

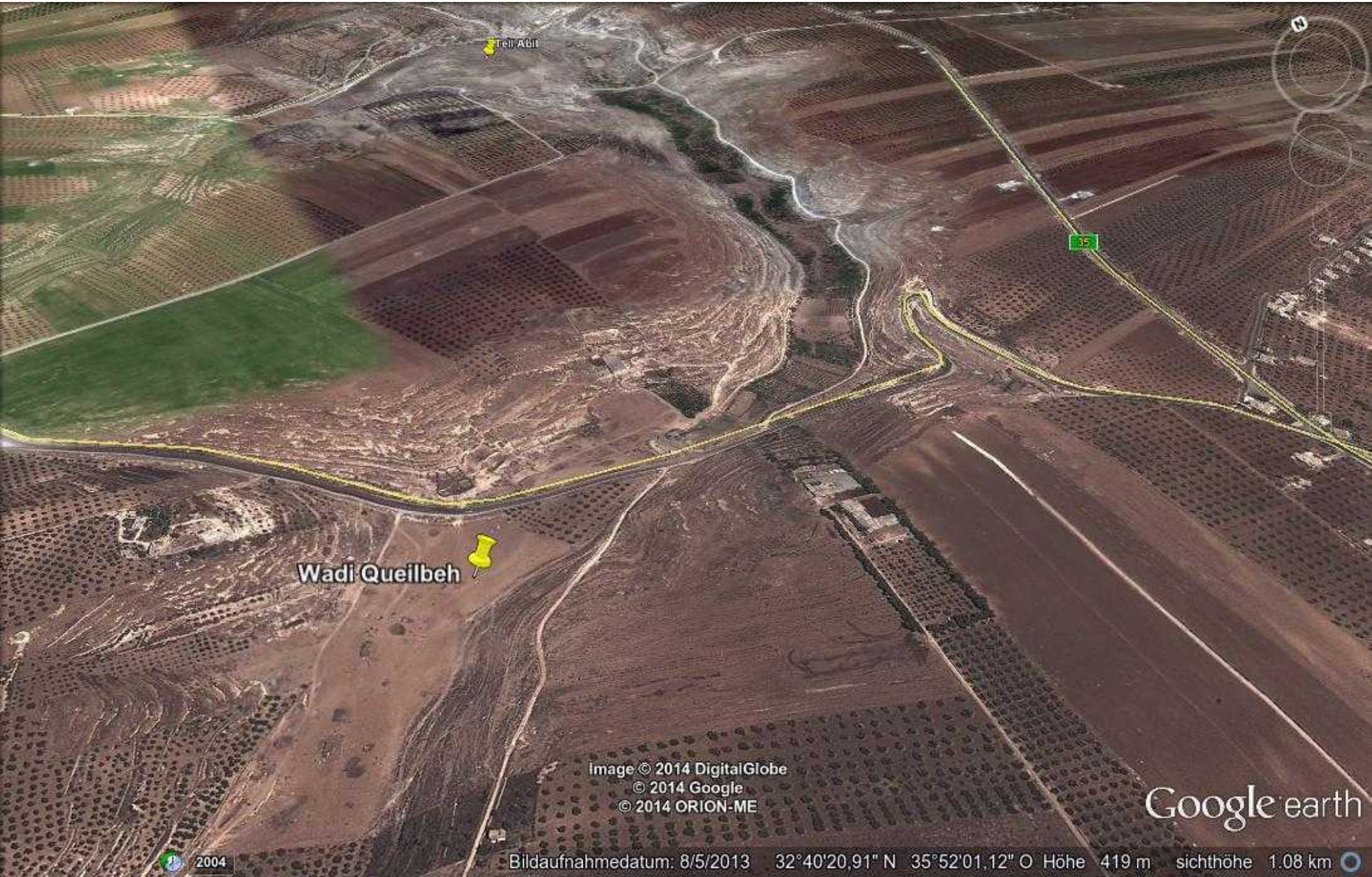
Variable soil properties on plateau: probably **reflecting past fields** (Lucke et al., 2005)

Highest pottery concentration on best soils: soil distribution **pre-dates** agriculture



Valley fill in Wadi Queilbeh at Abila of the Decapolis

(viewed by GoogleEarth, published according to fair use regulations, copyright: GoogleEarth, DigitalGlobe, ORION-ME)



No outcrops - digging necessary

Uniform stratigraphy: 4-5 m sediment fill until knickpoint

Two main sedimentation phases corresponding to ***debris flows*** during the Little Ice Ages (6th and 14th century AD)

Stratigraphy of fill

2 m colluvial material with stones, deposited mainly in **slumps** during **14th century AD** *(Lucke & Schmidt, 2017)*

2 m debris and breccia, including large boulders, fluvially sorted, deposited in **debris flows** during **6th century AD** *(Lucke & Schmidt, 2017)*

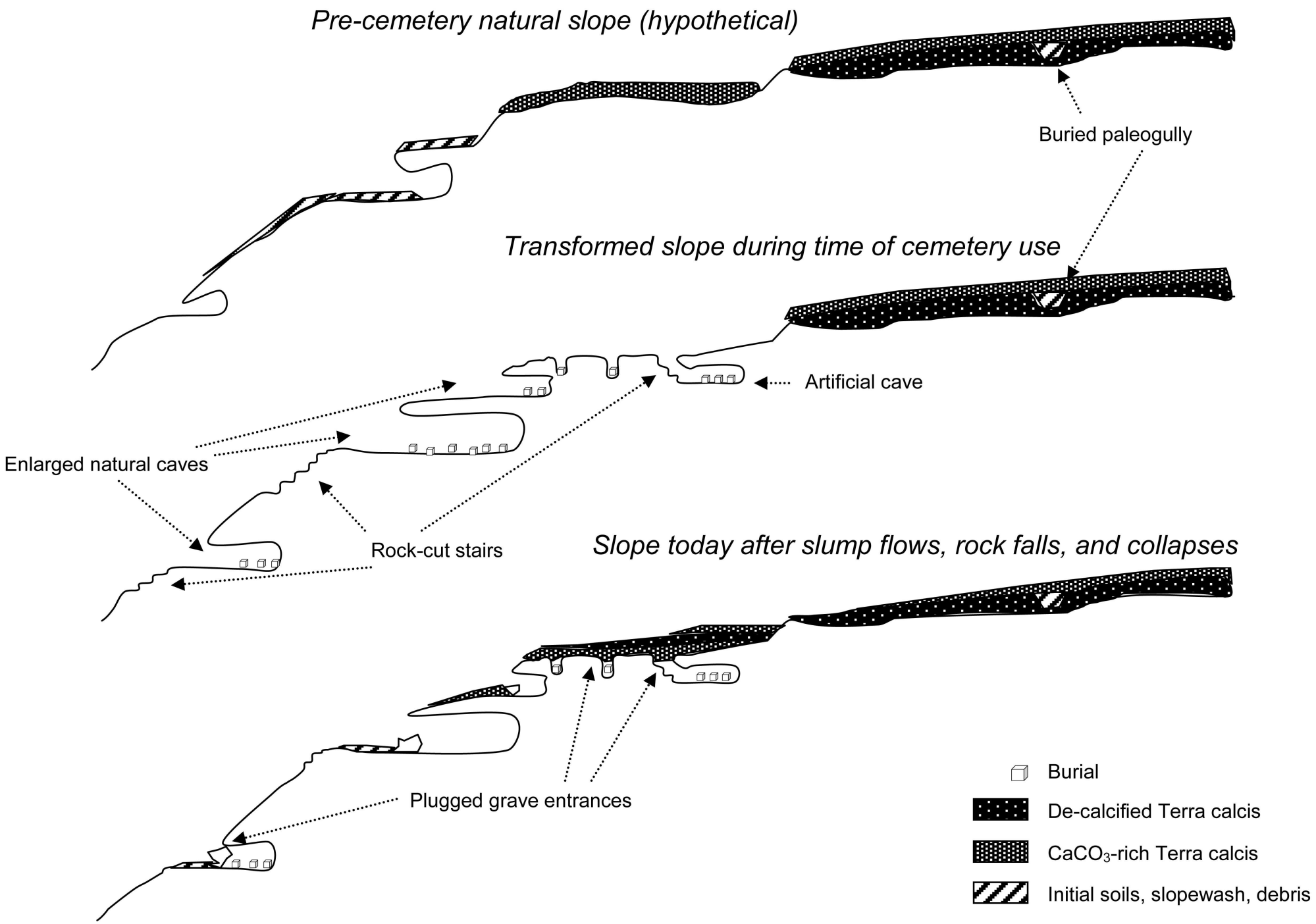
… well-sorted, well-rounded gravel suggesting **perennial creek** during Antiquity – **no colluvium** despite intense agricultural use… *(Lucke & Schmidt, 2017)*

… prismatic paleosol on cemented gravels at the bottom, dated to late Pleistocene (**dry valley**) *(Lucke & Schmidt, 2017)*

See also Lucke et al., 2012, 112, fig. 3.

Entrances to subterran graves of cemetery at plateau rim were *plugged*, and *not filled* by Terra calcis: erosion as ***slump flow*** *(near water saturation; Lucke&Müller, 2015; Lucke & Schmidt, 2017; Lucke, 2017;* exposed by treasure hunters)

Slump flows at limestone plateau rim near Abila



Summary evidence from Abila

Clay-rich Terrae calcis not transported grain-by-grain, *but by pseudoplastic debris flows, **slump flows**, and slumping* (agent: extreme rainfall)

Largest part of valley fill from pseudoplastic debris flows → **land use largely irrelevant** for sedimentation in valley

Land use altered soil properties on plateaus, but not the pattern of soil distribution: **fossil cultural landscape**

Disontinuous landscape development: long periods of stability interrupted by short phases of intense change correlating with **Little Ice Ages**

Premises of many reconstructions of past landscape changes: *linear relationships & single-grain transport*

Erosion → Sedimentation → Reconstruction from dated sediment body

<u>Questionable premises:</u>

a) Sediments transported grain-by-grain (?)

b) Continuous process (?)

c) Erosion = deposition (?)

d) <u>Annual</u> deposition rates (?) (what about events?)

e) mass movements = fertility losses (?)

For example figure showing calculation of mean annual sedimentation rates based on OSL-ages of clay-rich sediment bodies see e.g. Fuchs et al. 2004, 344 (fig. 9).

Past population numbers = proxy of erosion-sedimentation risk?

Impact of climate changes = variations of *annual averages*?

2a) Demographic estimates as proxy for land use intensity=erosion risk (?)

→ ***past land use systems unknown!***

2b) Mean annual precipitation as proxy for impact of climate fluctuations (?)

→ ***do not reflect extreme events!***

For example figures for correlations of calculated mean annual sedimentation rates with demographic estimates and average precipitation, see Fuchs et al. 2004, 344 (fig. 9) based on mean annual rainfall calculated for far-away Soreq cave (Bar-Matthews et al. 1998, 206, fig. 9.2)

Questionable indicators based on incorrect premises: *Mean annual precipitation* and *demographic estimates* are **not suited** to explain highly variable sedimentation processes in drylands!

Conclusions for land degradation debate

- Many reconstructions of past erosion-sedimentation processes in drylands such as Jordan are based on *too simple premises*, such as *grain-by-grain transport and deposition* of sediment
- Accordingly, many models *must fail* to predict erosion risks
- Simplified assumptions on the role of climate (e.g. based on *mean annual averages*) are not acceptable in drylands or Med. climates
- The potential role of extreme events *(climatic, seismic, and cosmic; Lucke, 2017)* is not sufficiently considered
- Past land use systems are *usually completely unknown*
- Conclusions on the impact of past land use *should be based on* (spatially precise) *evidence*; estimates e.g. based on demographic estimates or cultural prejudice are misleading and **created myths** with **dangerous consequences** for planning.

References

Bar-Matthews, M., Ayalon, A., Kaufmann, A., 1998. Middle to Late Holocene (6500 yr Period) Paleoclimate in the Eastern Mediterranean Region from Stable Isotopic Composition of Speleothems from Soreq Cave, Israel. In: Issar, A., Brown, N. (eds.), Water, Environment and Society in Times of Climatic Change, Kluwer Academic Publishers, Dordrecht, 203-215.

Fuchs, M., Lang, A., Wagner, G.A., 2004. The history of Holocene soil erosion in the Phlious Basin, NE Peloponnese, Greece, based on optical dating. The Holocene 14, 3, 334-345.

Lucke, B., Schmidt, M., al-Saad, Z., Bens, O., Hüttl, R.F., 2005. The Abandonment of the Decapolis Region in Northern Jordan – Forced by Environmental Change? Quaternary International 135, Special issue: Geochronology and Environmental Reconstruction: a Tribute to Glenn A. Goodfriend, 65-81.

Lucke, B., 2008. Demise of the Decapolis. Past and Present Desertification in the Context of Soil Development, Land Use, and Climate. OmniScriptum, Saarbrücken. First published online in 2007, dissertation at BTU Cottbus, http://se6.kobv.de:8000/btu/volltexte/2007/343/
(URN: http://nbn-resolving.de/urn:nbn:de:kobv:co1-opus-3431).

Lucke, B., Shunnaq, M., Walker, B., Shiyab, A., Muheisen, Z., Sabahba, H., Bäumler, R., Schmidt, M., 2012. Questioning Transjordan's Historic Desertification: a Critical Review of the Paradigm of 'Empty Lands'. Levant 44/1, 101-126.

Lucke, B., Müller, A., 2015. Air photos as tool to trace mass movements in Wadi Queilbeh from 1978 – 2009 as compared to Wadi Ziqlab in the context of record levels of daily rainfall in Jordan. In: Lucke, B., Bäumler, R., Schmidt, M. (eds.), Soils and Sediments as Archives of Environmental Change. Geoarchaeology and Landscape Change in the Subtropics and Tropics. Fränkische Geographische Gesellschaft, Erlangen, 23-32.

Lucke, B., Schmidt, C., 2017. Debris flows, soil creep, and heavy rains in the Wadi Queilbeh, northern Jordan. Zeitschrift für Geomorphologie, Vol. 61, Suppl. 1, 159–201

Lucke, B., 2017. Landscape transformations in the context of soil development, land use, and climate. A comparison of marginal areas in Jordan, Mexico, and Germany. Relief Boden Paläoklima 26, Schweitzerbart Science Publishers.

References

Bar-Matthews, M., Ayalon, A., Kaufmann, A., 1998. Middle to Late Holocene (6500 yr Period) Paleoclimate in the Eastern Mediterranean Region from Stable Isotopic Composition of Speleothems from Soreq Cave, Israel. In: Issar, A., Brown, N. (eds.), Water, Environment and Society in Times of Climatic Change, Kluwer Academic Publishers, Dordrecht, 203-215.

Fuchs, M., Lang, A., Wagner, G.A., 2004. The history of Holocene soil erosion in the Phlious Basin, NE Peloponnese, Greece, based on optical dating. The Holocene 14, 3, 334-345.

Lucke, B., Schmidt, M., al-Saad, Z., Bens, O., Hüttl, R.F., 2005. The Abandonment of the Decapolis Region in Northern Jo… …pecial issue: Geochronolo…

Lucke, B., … …ntext of Soil Developmen… …e in 2007, dissertation a… (URN: http://…

Lucke, B., S… …dt, M., 2012. Questioning … …ands'. Levant 44/1, 101-12…

Lucke, B., M… …1978 – 2009 as compared … …B., Bäumler, R., Schmidt, M. (eds.), Soils and Sediments as Archives of Environmental Change. Geoarchaeology and Landscape Change in the Subtropics and Tropics. Fränkische Geographische Gesellschaft, Erlangen, 23-32.

Lucke, B., Schmidt, C., 2017. Debris flows, soil creep, and heavy rains in the Wadi Queilbeh, northern Jordan. Zeitschrift für Geomorphologie, Vol. 61, Suppl. 1, 159–201

Lucke, B., 2017. Landscape transformations in the context of soil development, land use, and climate. A comparison of marginal areas in Jordan, Mexico, and Germany. Relief Boden Paläoklima 26, Schweitzerbart Science Publishers.

Thank you