

Evolutionary tipping points in changing environments

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Environments change and populations adapt

environmental change

genetic adaptation

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warmer springs



genetic adaptation

earlier birth dates
Réale et al. 2003

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later autumns



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Bradshaw & Holzapfel 2001

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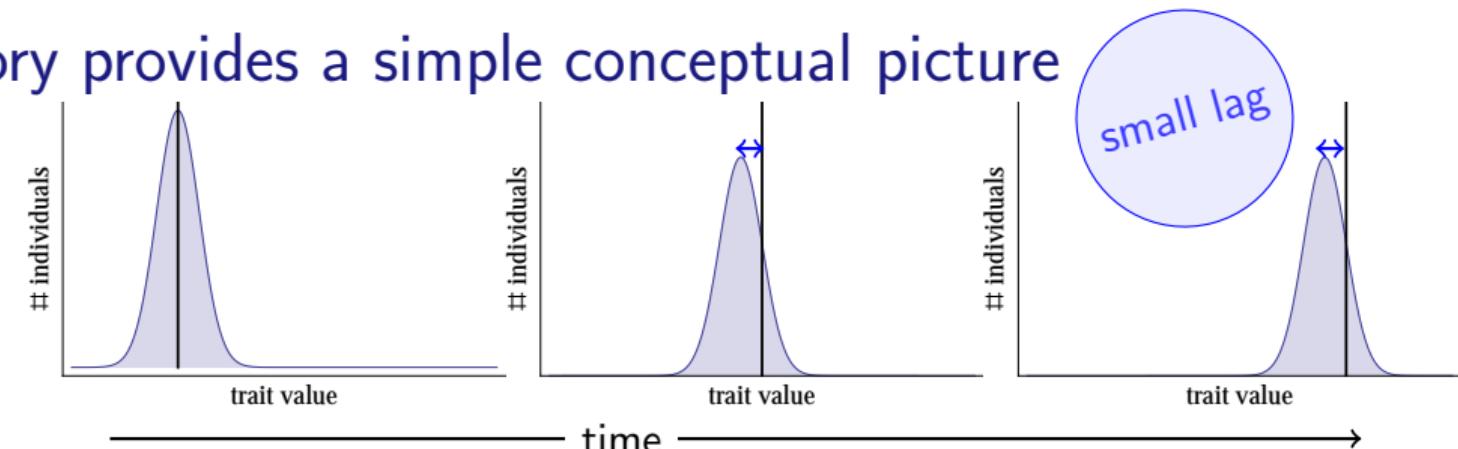
shorter time to flower
Franks et al. 2007

Simple theory provides a simple conceptual picture

Critical rate of environmental change, $k_c = f(\text{variance, selection})$

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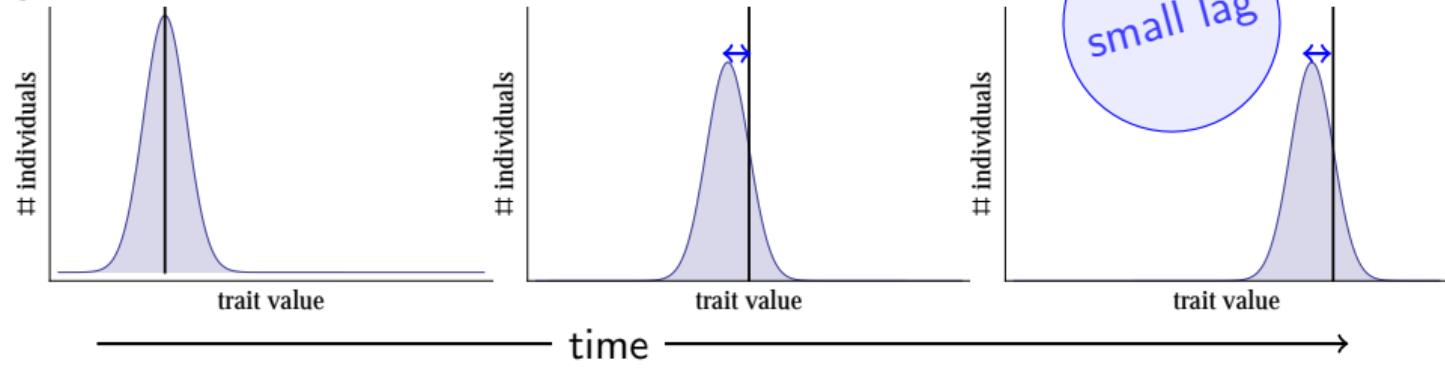
if $k < k_c$



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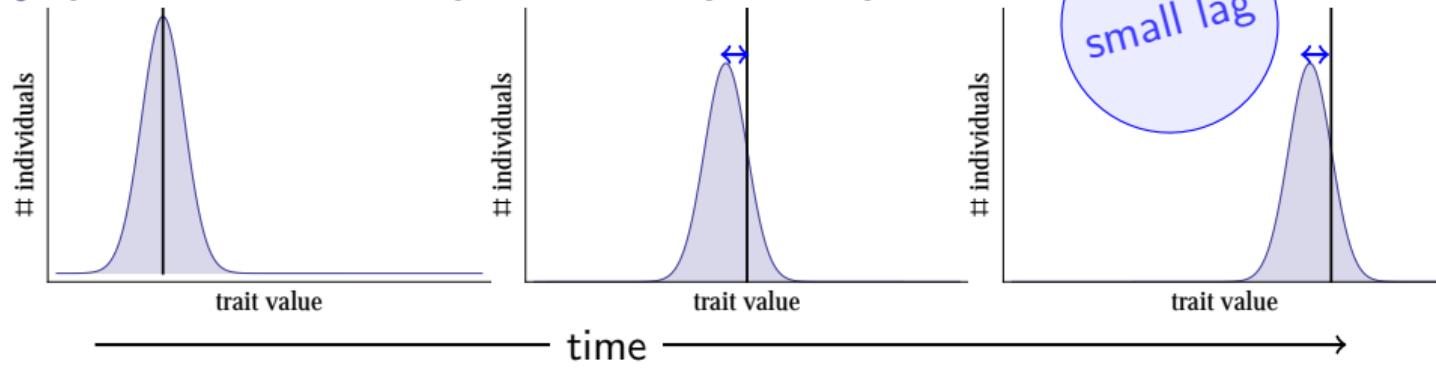
if $k < k_c$
⇒ persist



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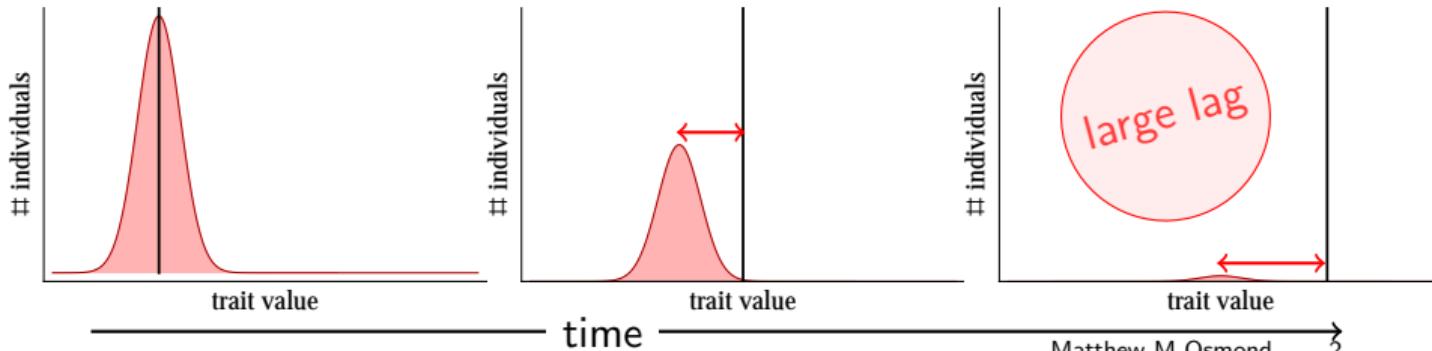
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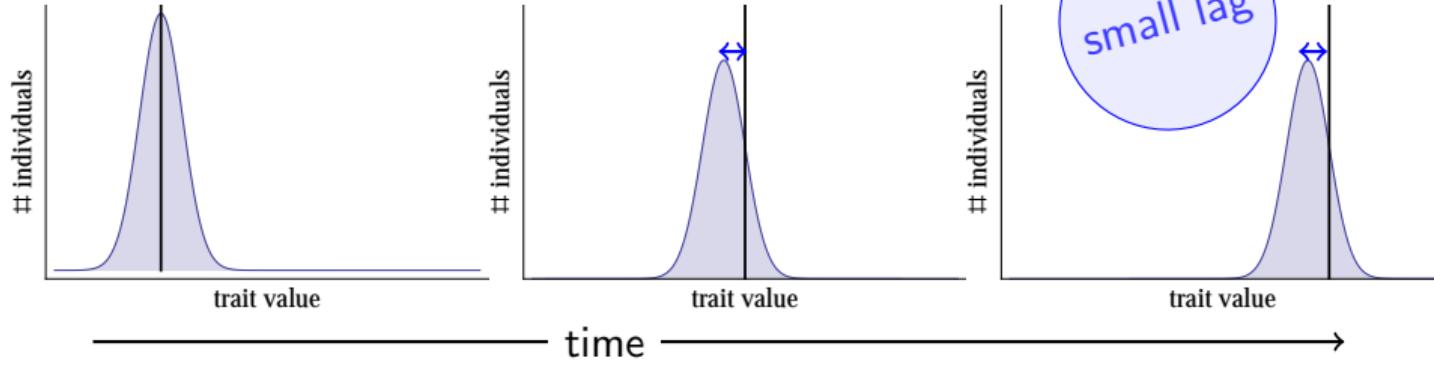
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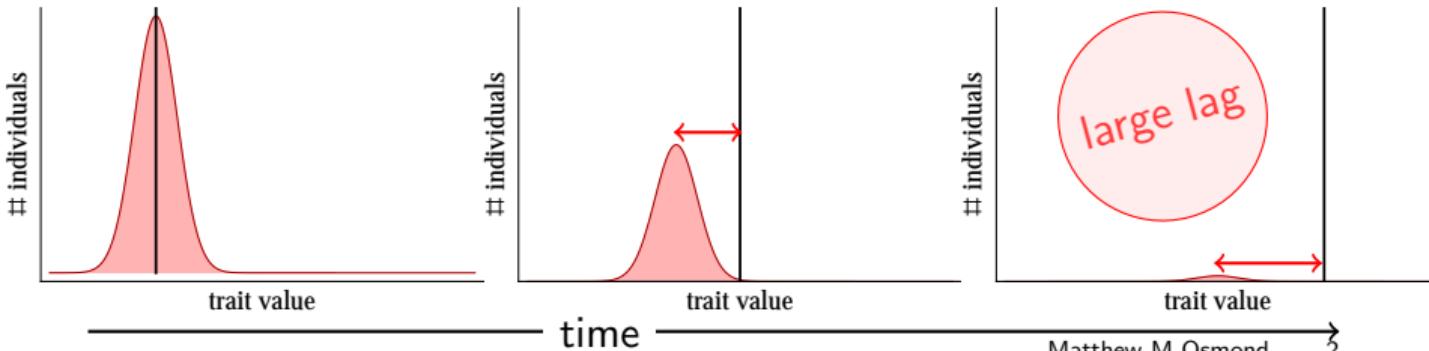
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Critical rate of environmental change, $k_c = f(\text{variance, selection})$

if $k_c < k$
⇒ extinct



Simple theory makes simple predictions

critical rate

study

Simple theory makes simple predictions

critical rate

$\sim 0.4\sigma_P/\text{gen}$



study

Aitken *et al.* 2008

Simple theory makes simple predictions

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~ 0.1 minutes heat-knockdown/gen



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Willi & Hoffmann 2009

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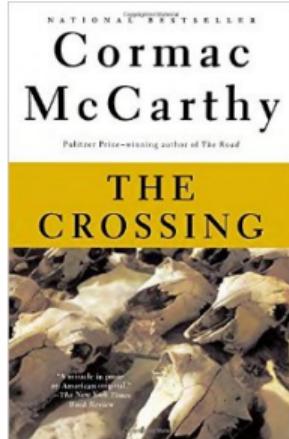
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$\sim 0.5^\circ\text{C}/\text{year}$



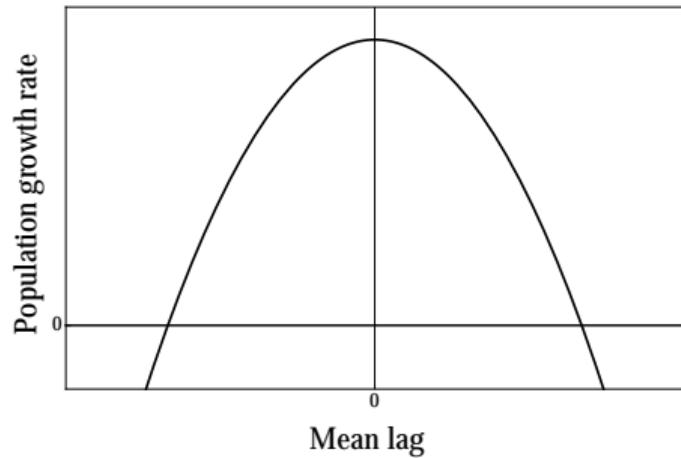
Vedder *et al.* 2013

But could the simple theory be too simple?

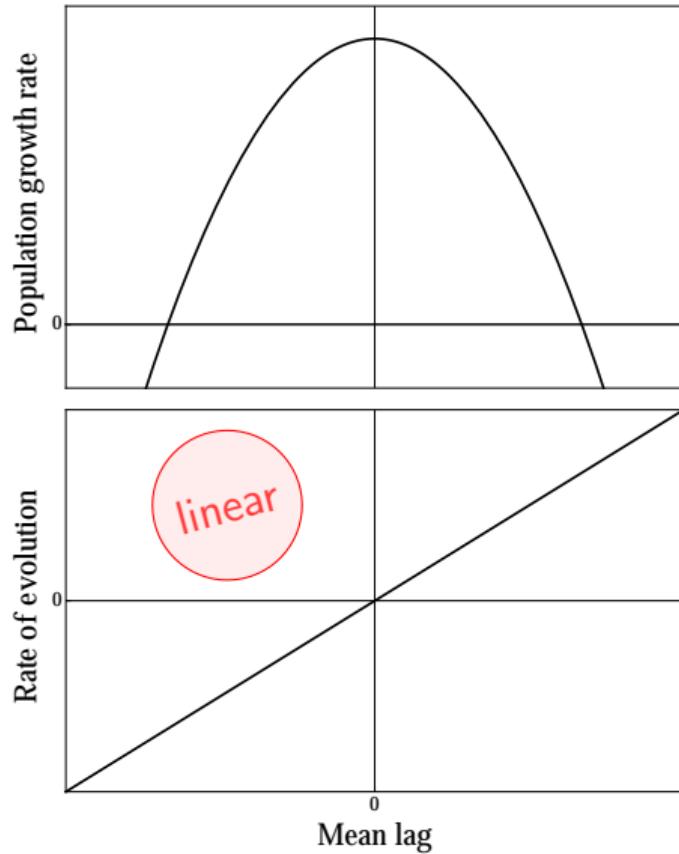


"... a bad map [is] worse than no map at all for it engenders[...] in the traveler a false confidence and might easily cause [them] to set aside those instincts which would otherwise guide [them]..."

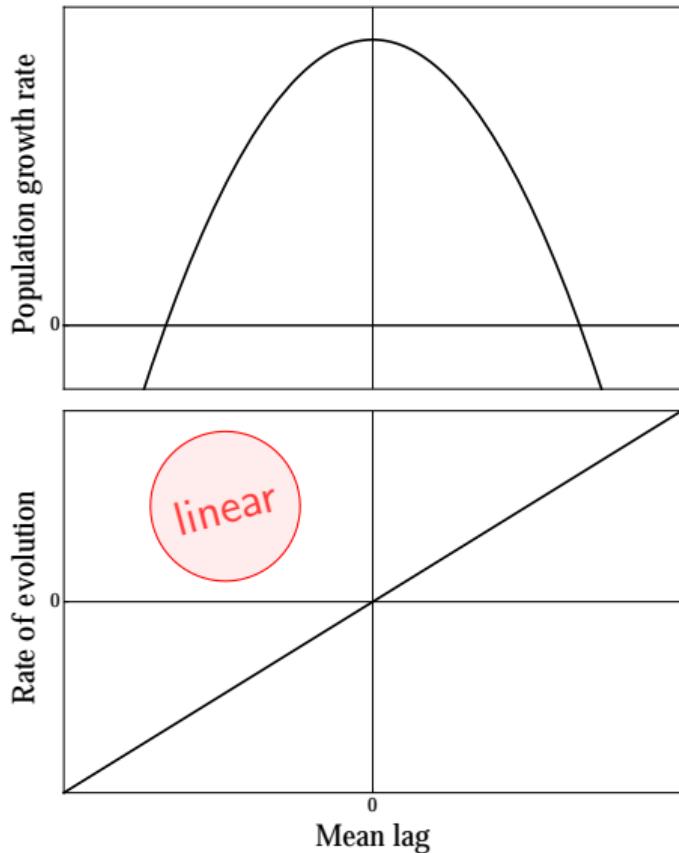
One big common (implicit) assumption



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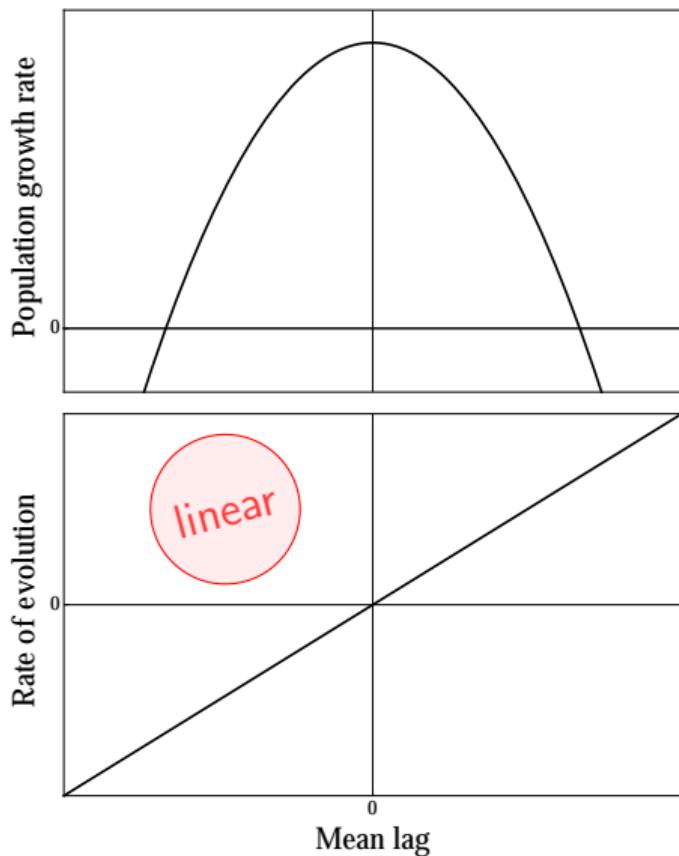
One big common (implicit) assumption



prominent examples

- Pease *et al.* 1989
- Lynch *et al.* 1991
- Lynch & Lande 1993
- Charlesworth 1993
- Bürger & Lynch 1995
- Bürger 1999
- Gomulkiewicz & Houle 2009
- Polechová *et al.* 2010
- Chevin *et al.* 2010
- Matuszewski *et al.* 2015
- Marshall *et al.* 2016
- Aguilée *et al.* 2016

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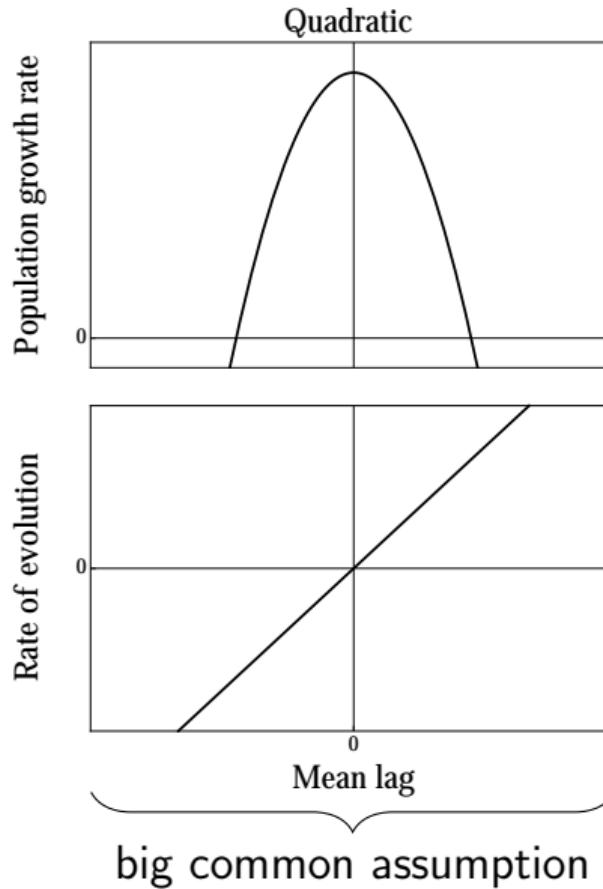


prominent examples

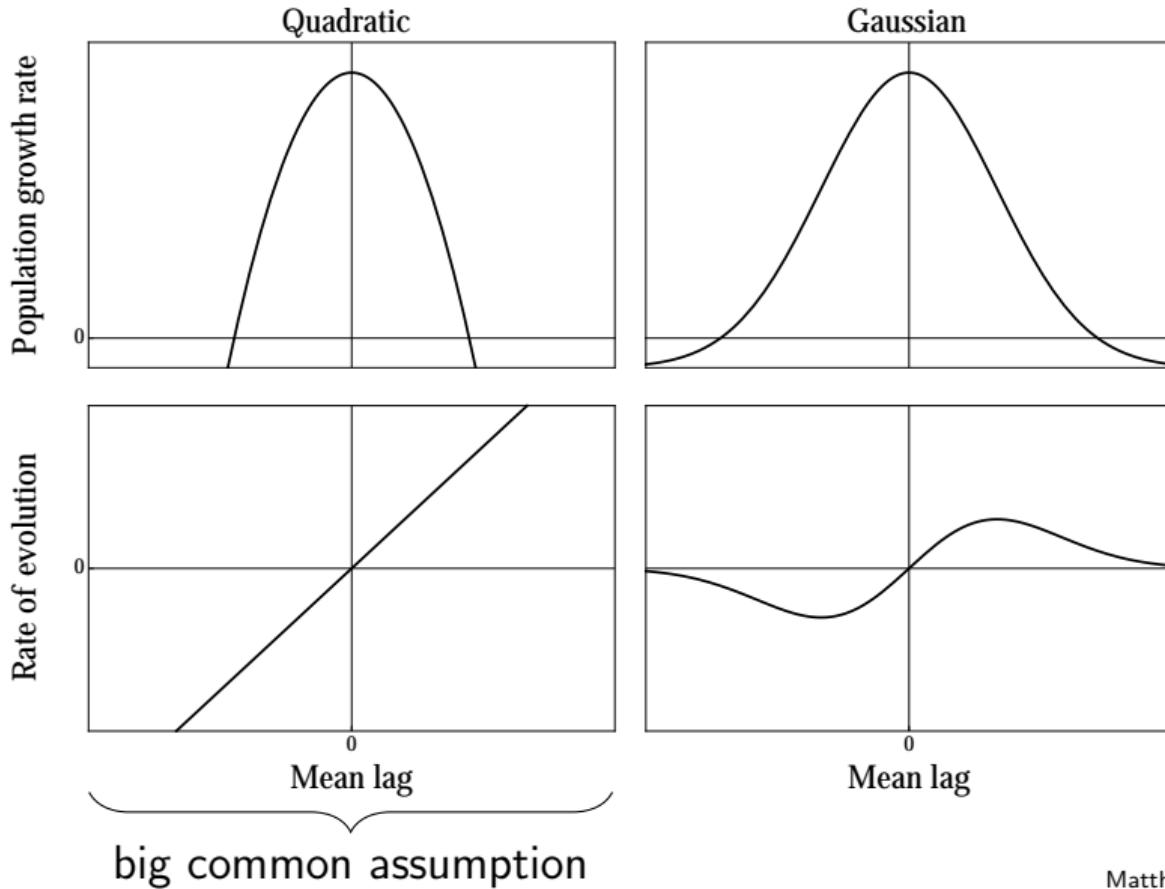
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Q. is our conceptual picture robust to changes in the **big common assumption?**

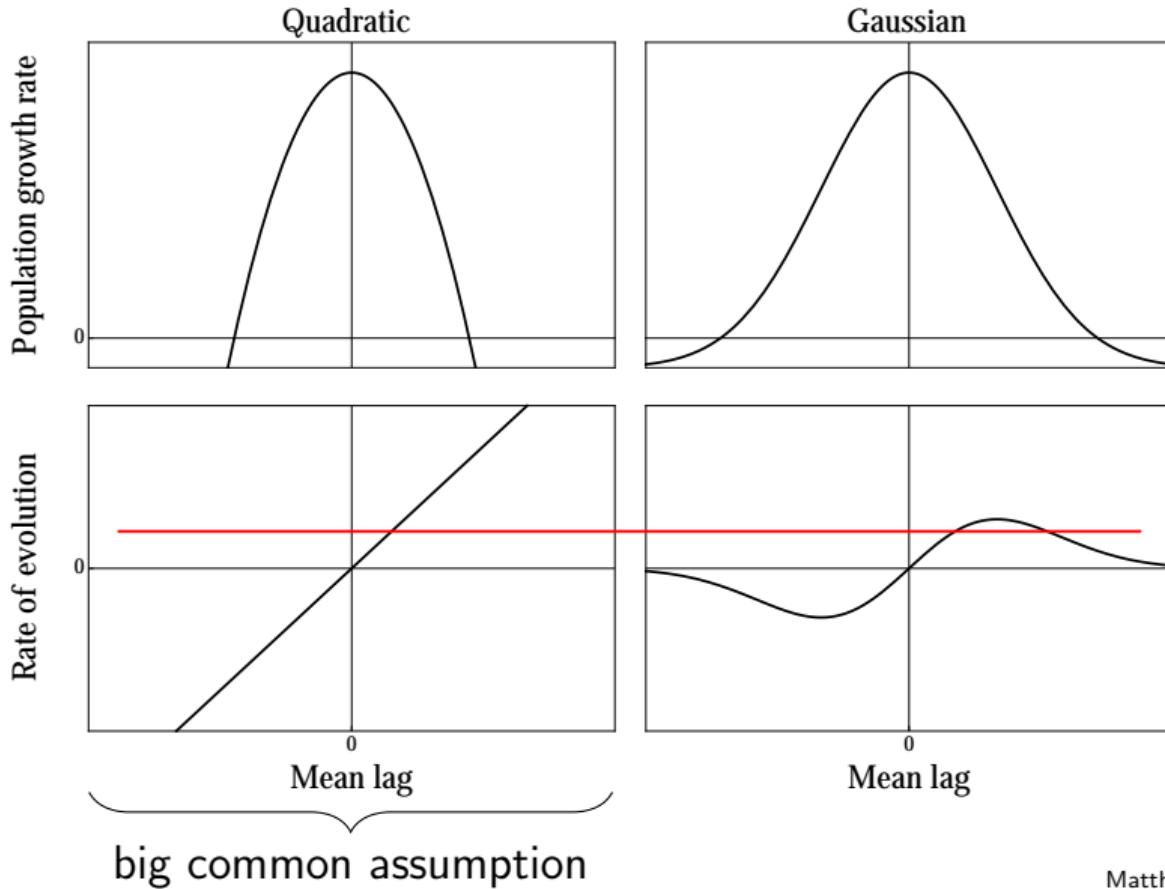
Lack of steady-state when selection finite



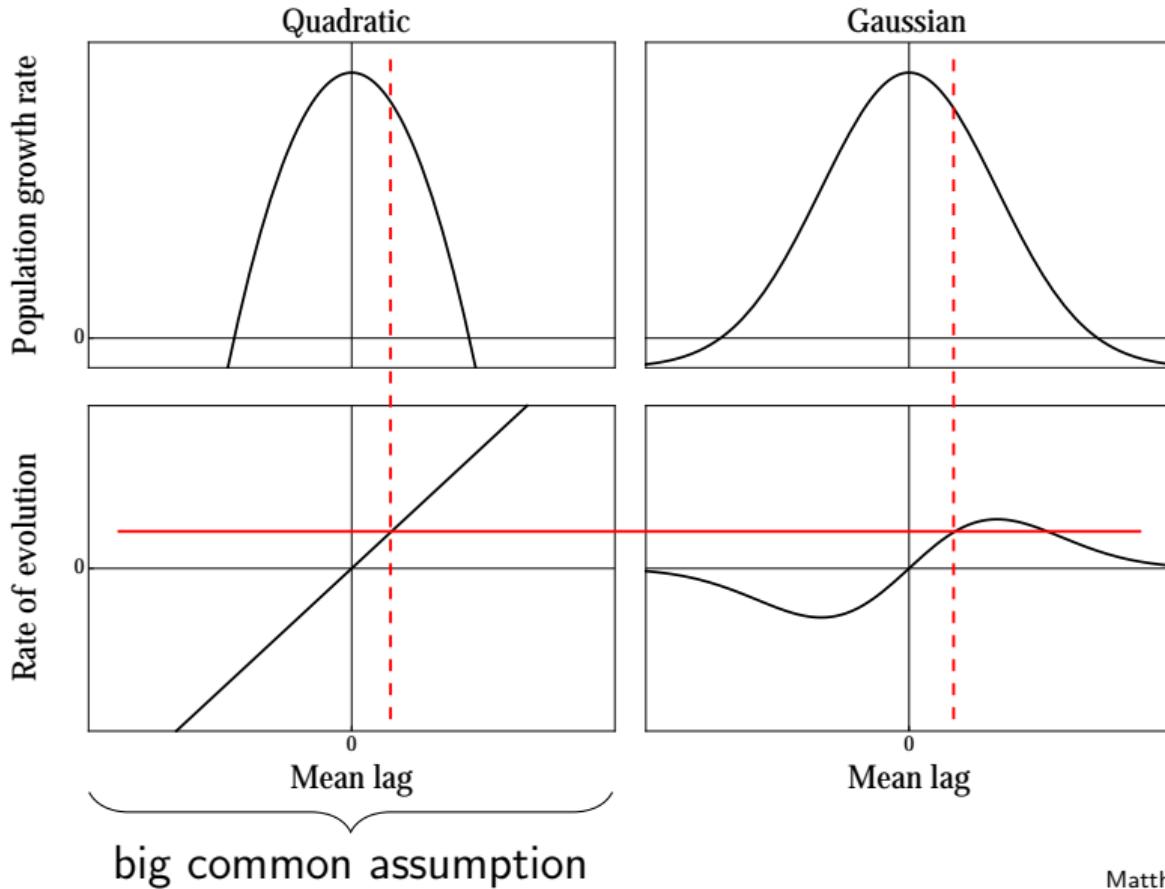
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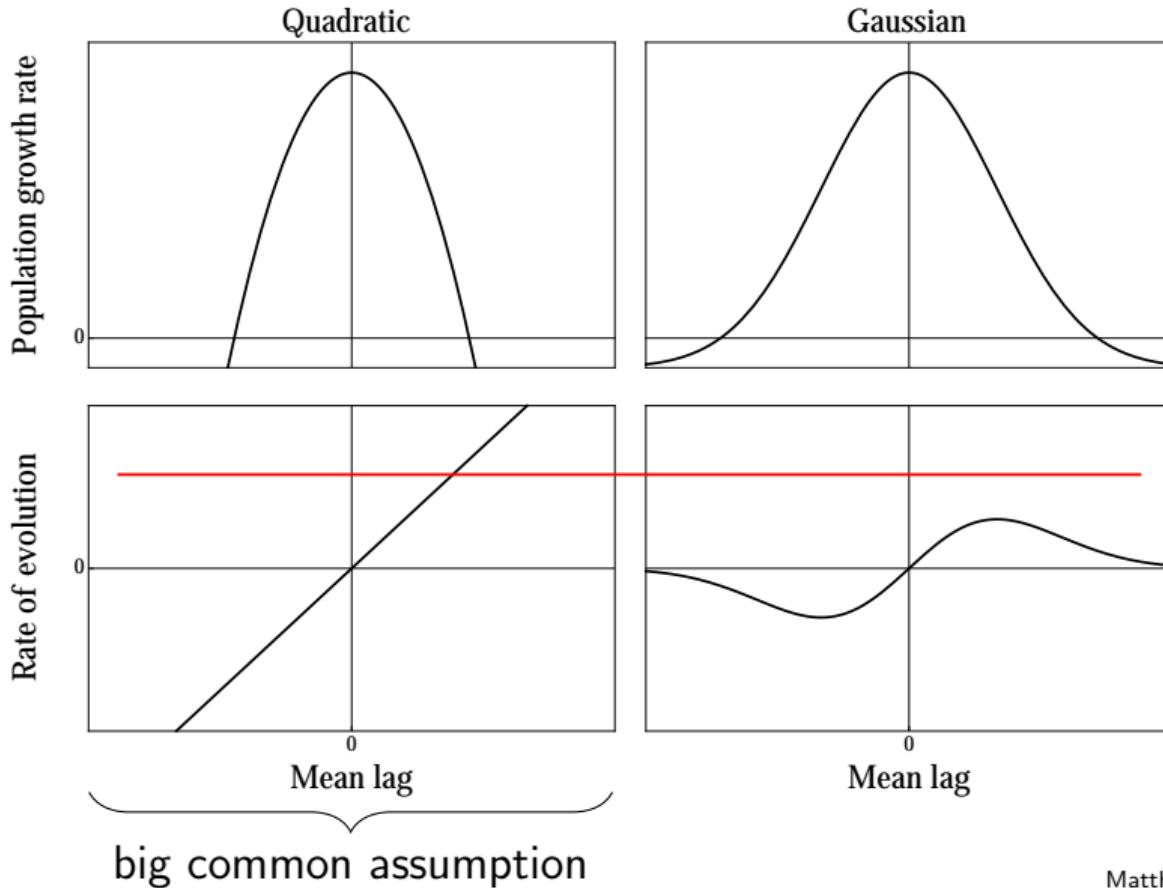
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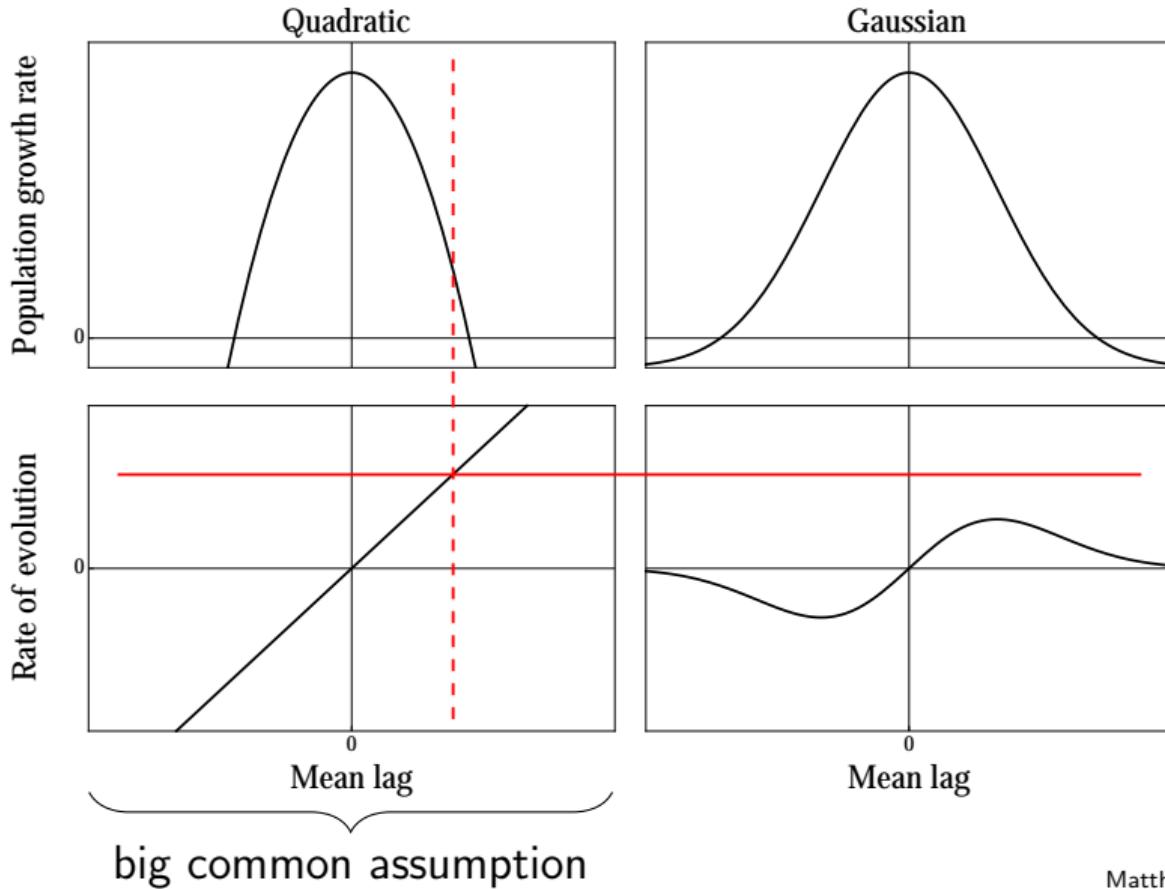
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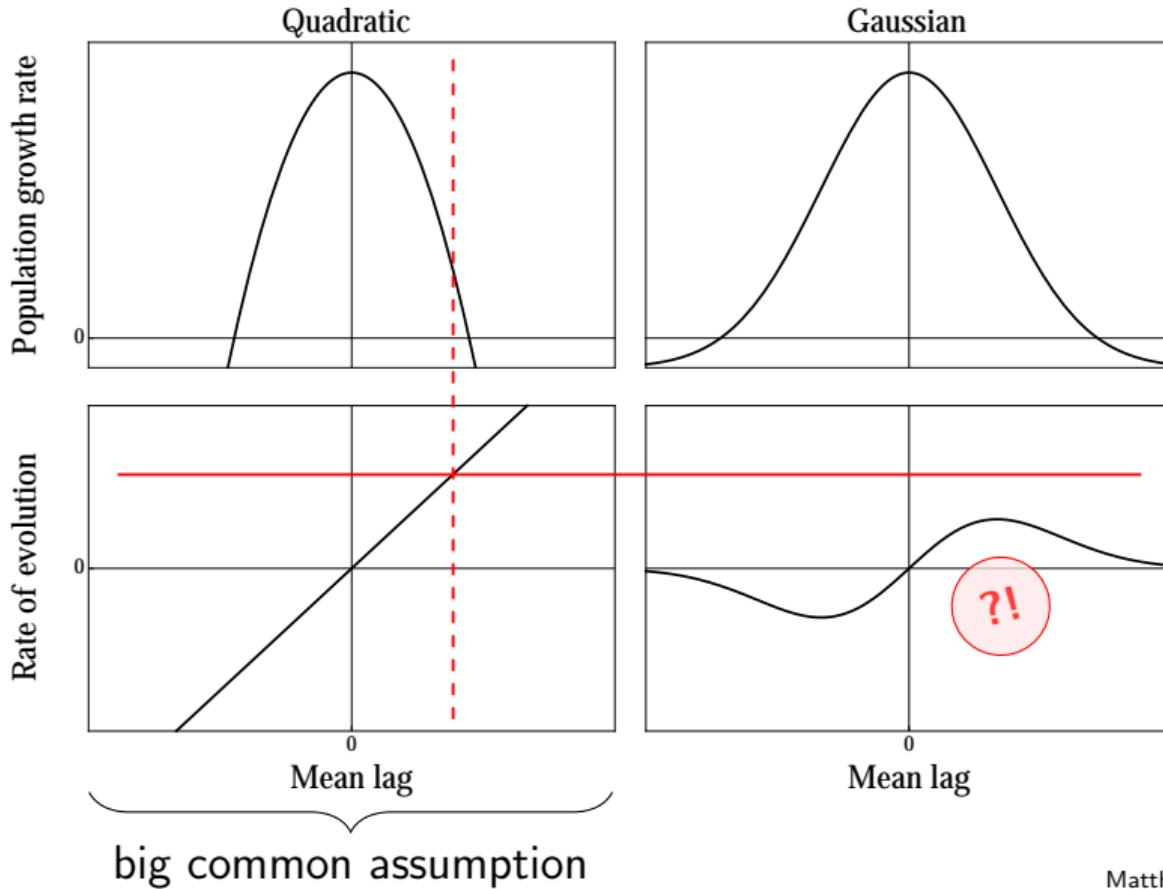
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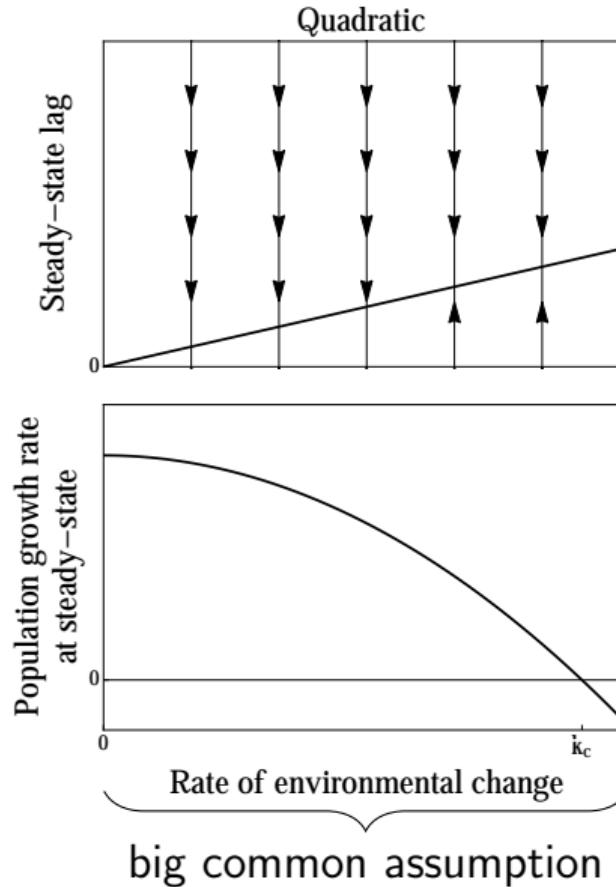
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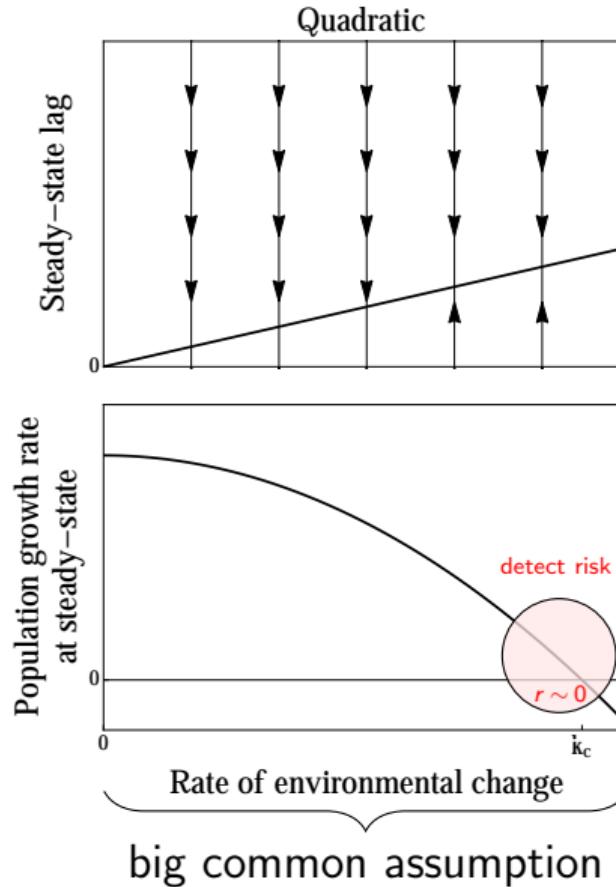
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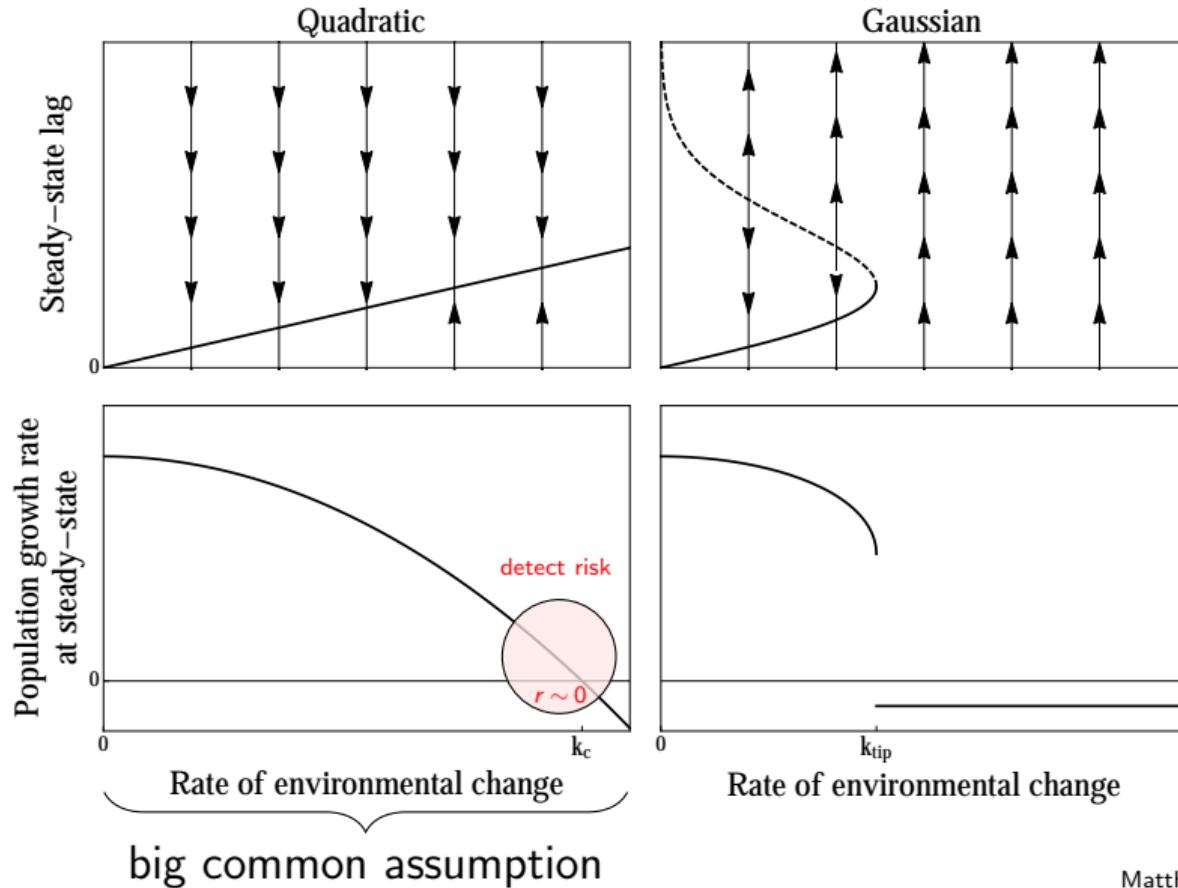
Loss of steady-state causes “tipping point”



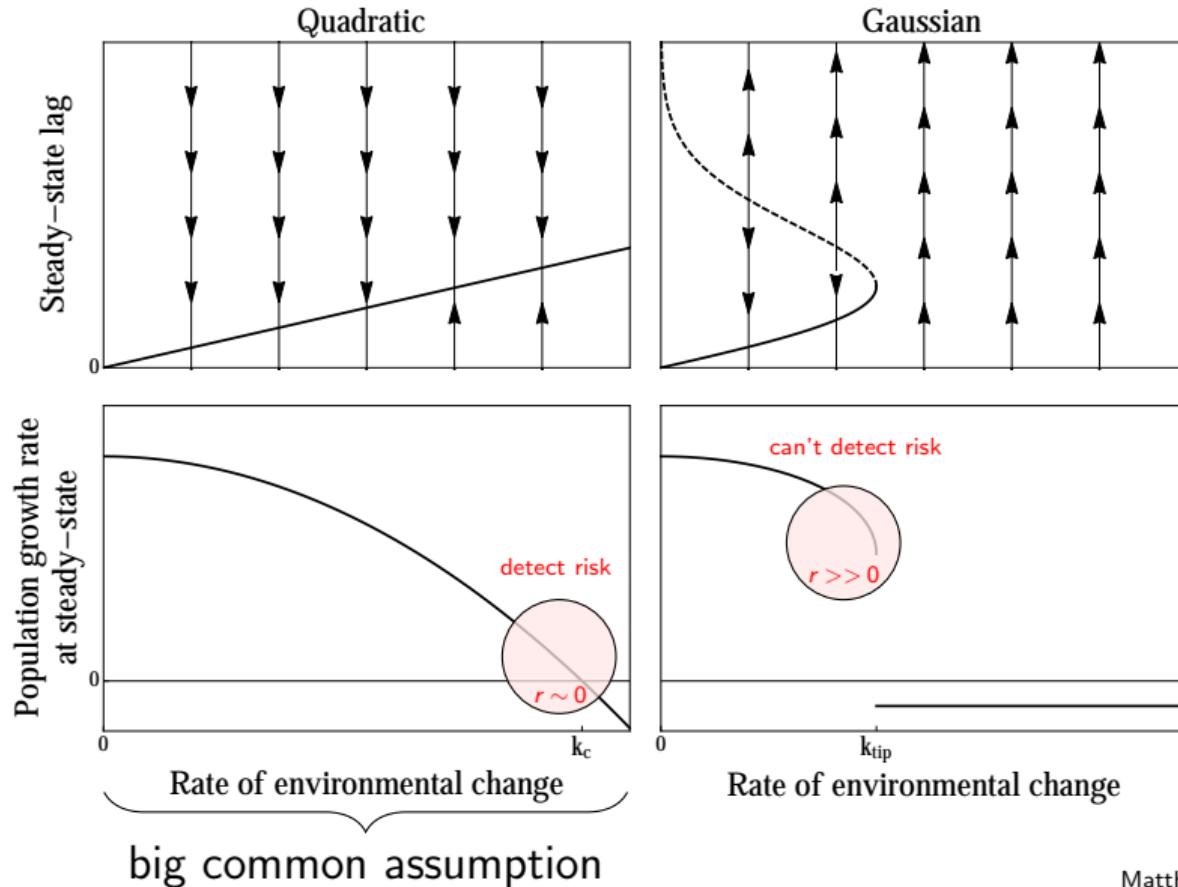
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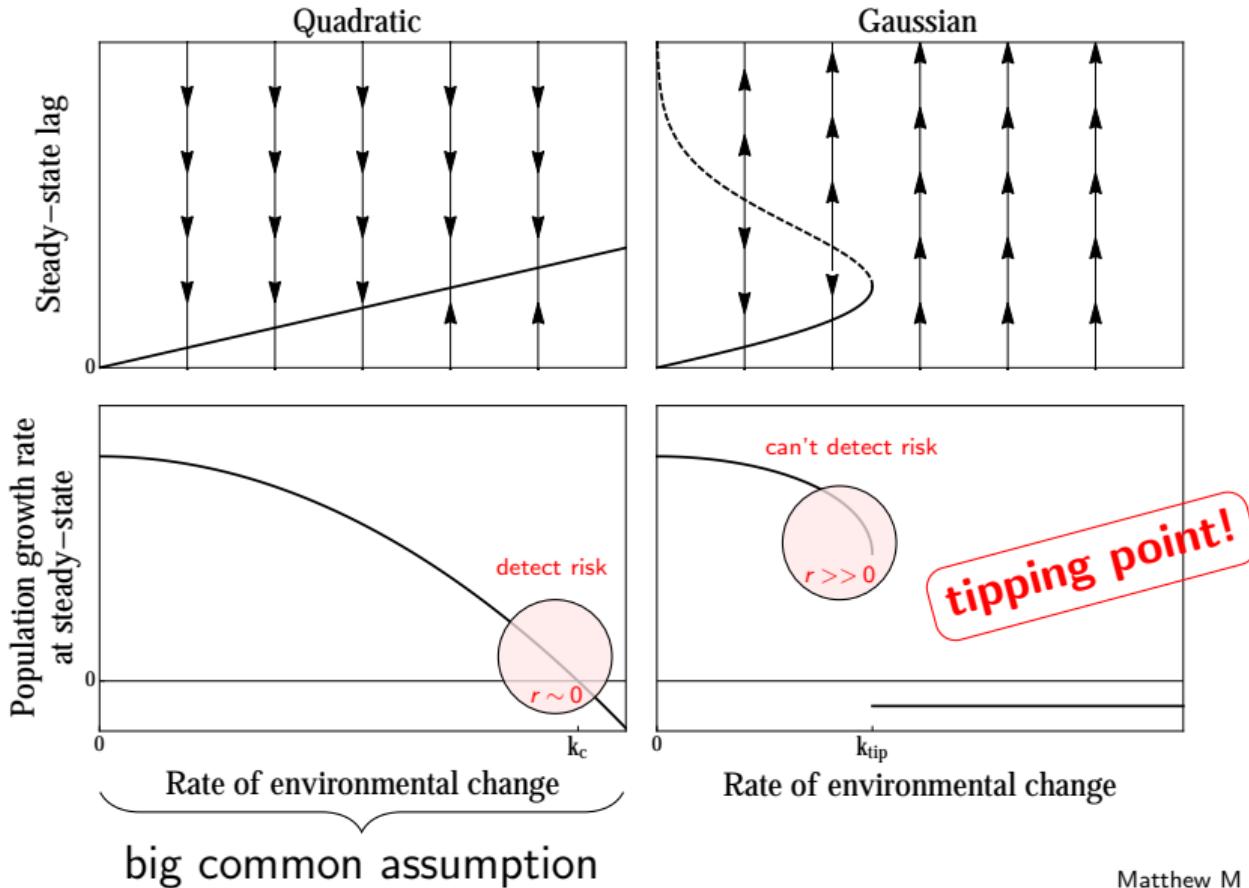
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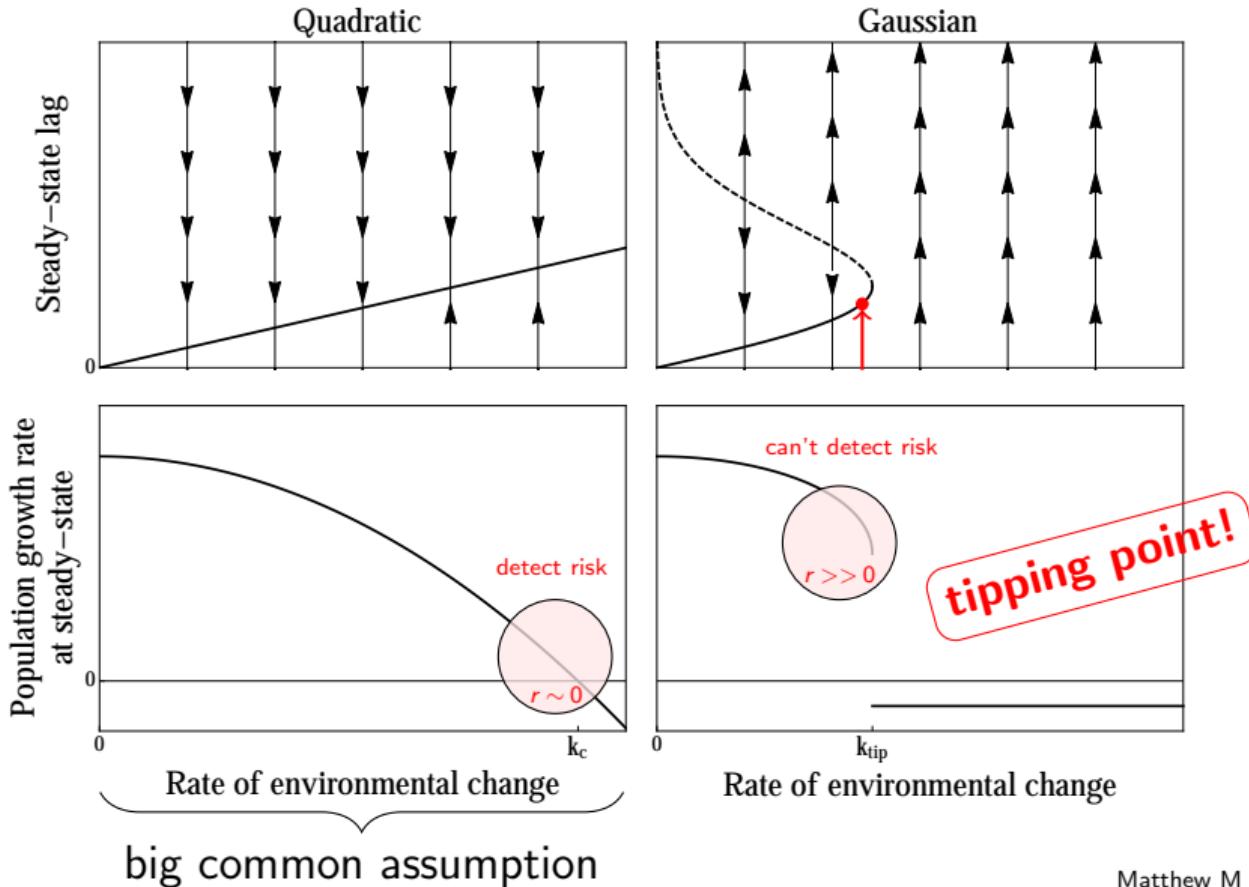
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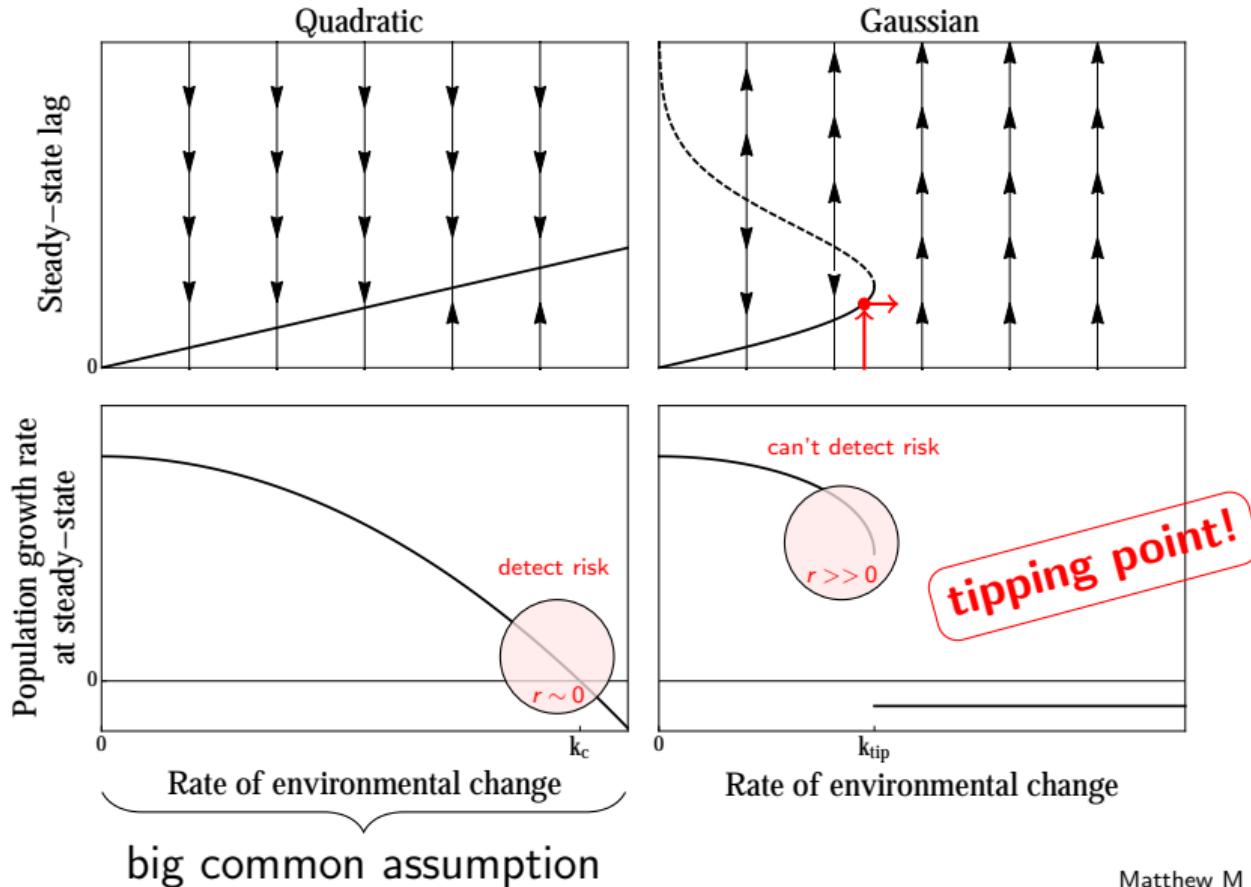
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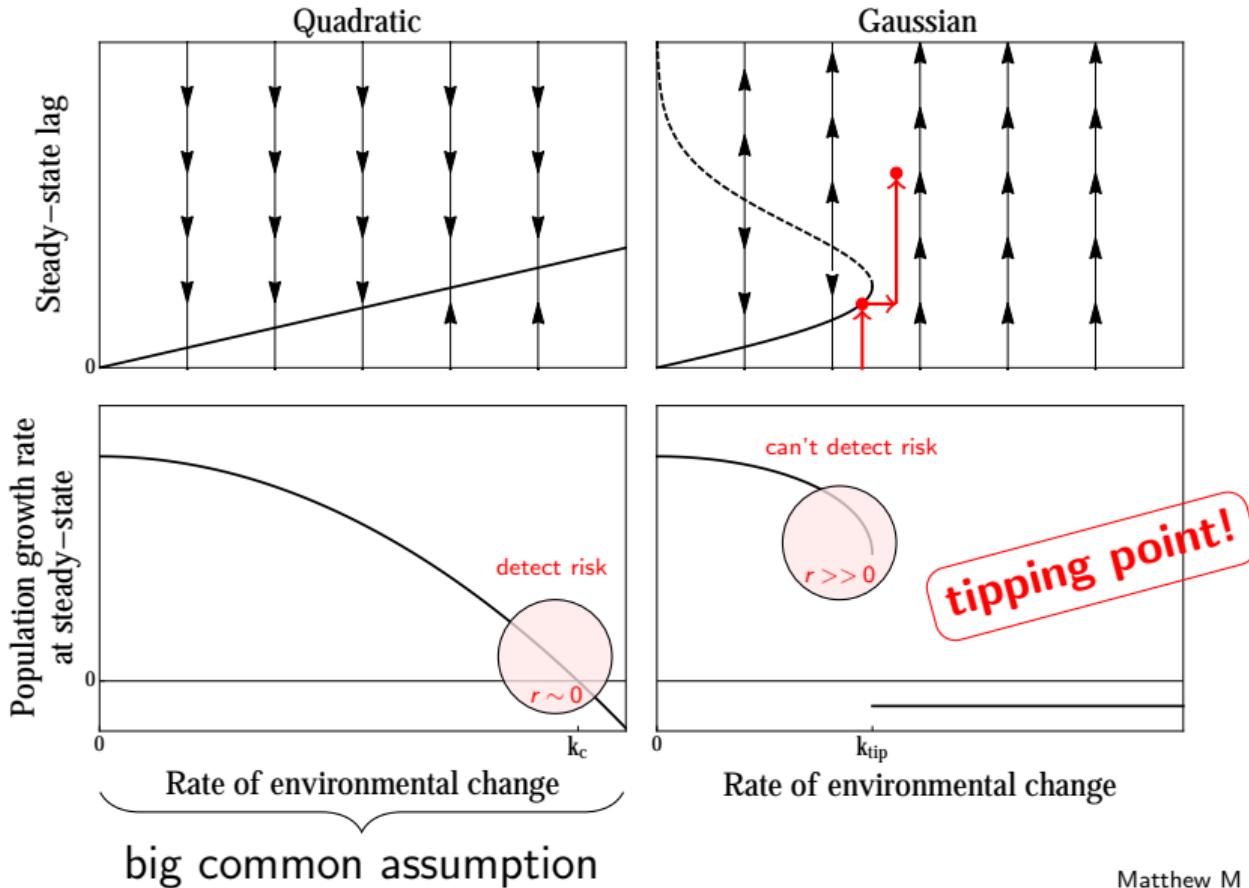
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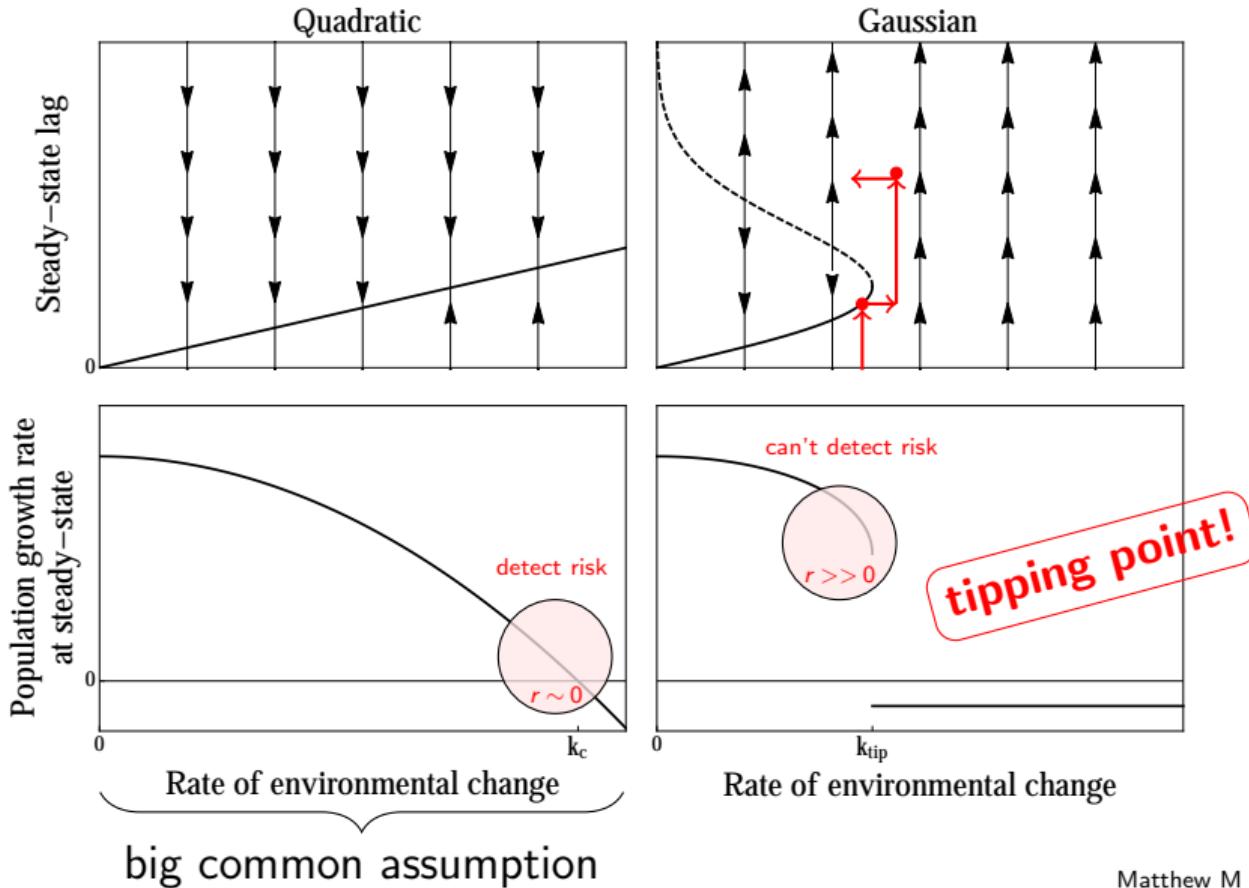
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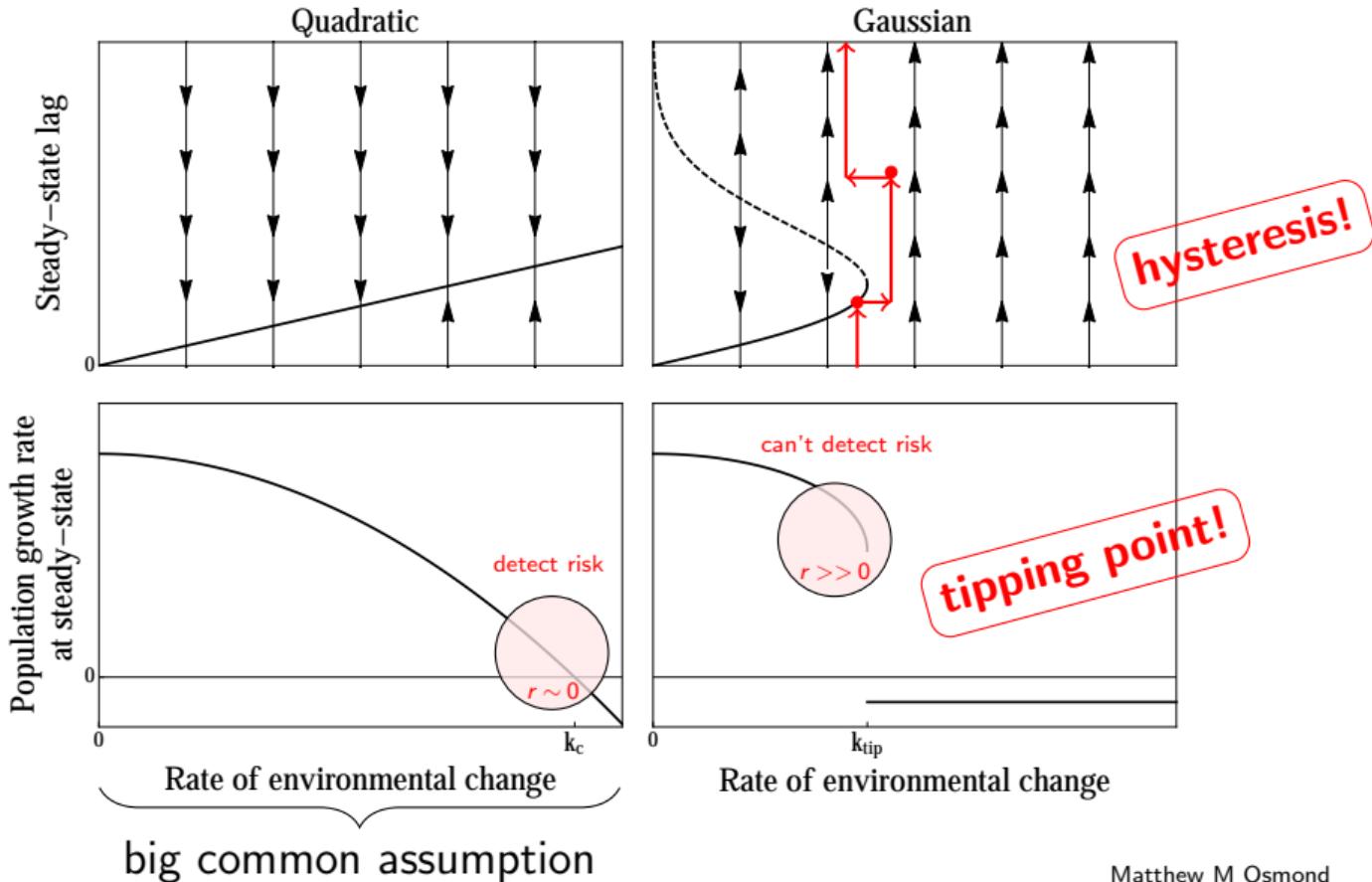
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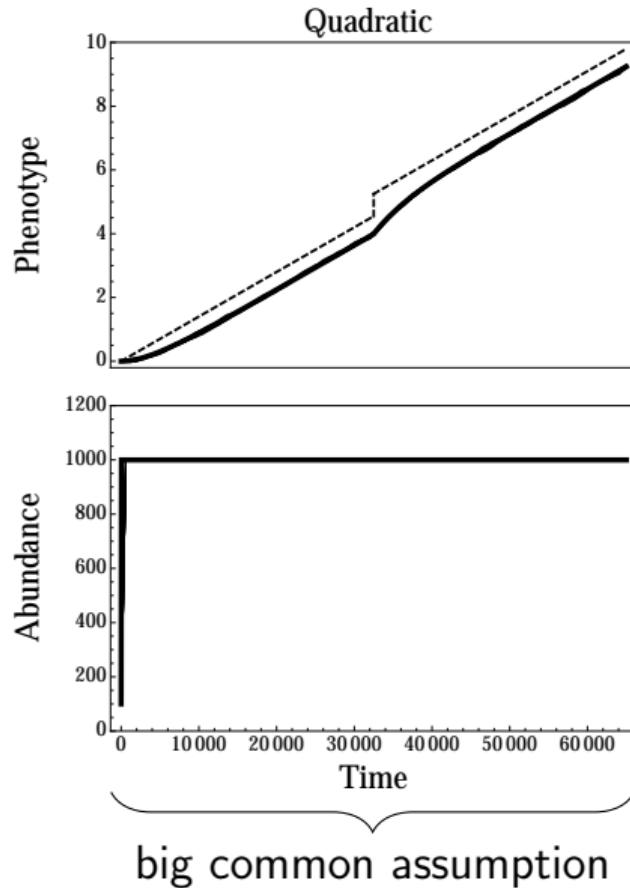
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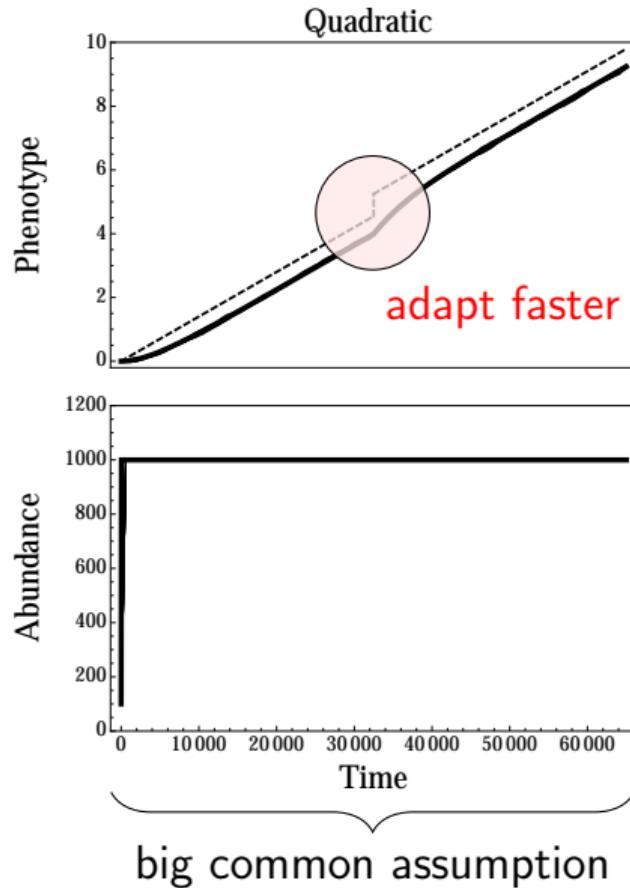
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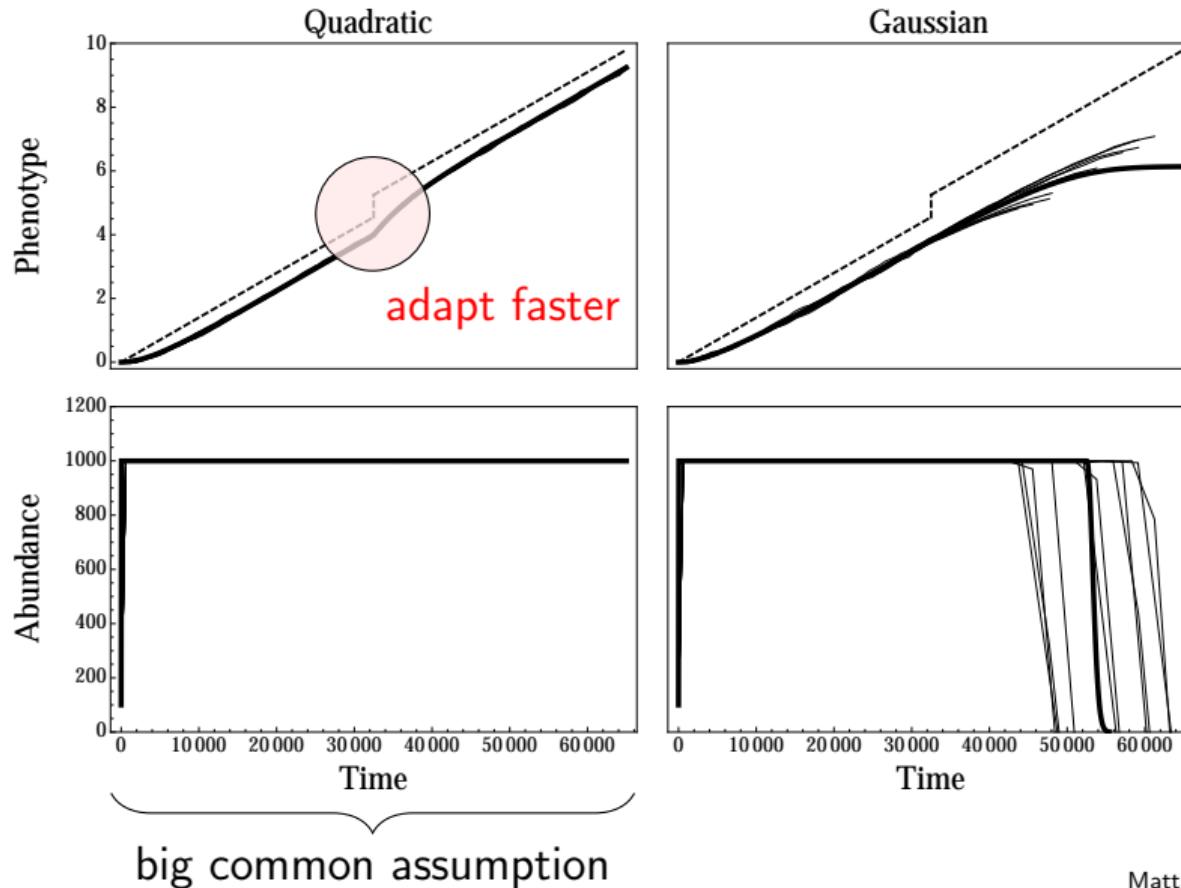
“Evolutionary hysteresis” creates an extinction debt



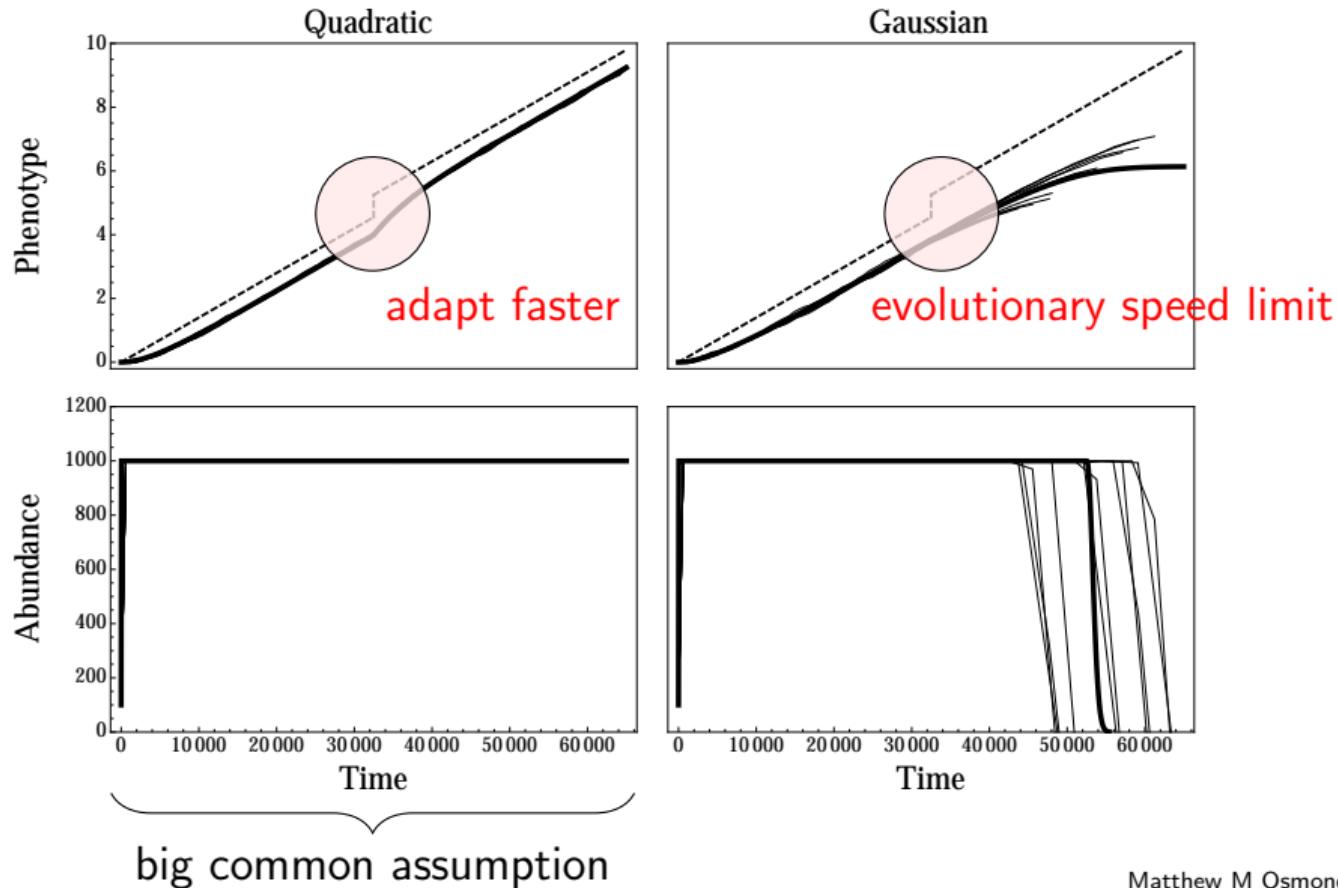
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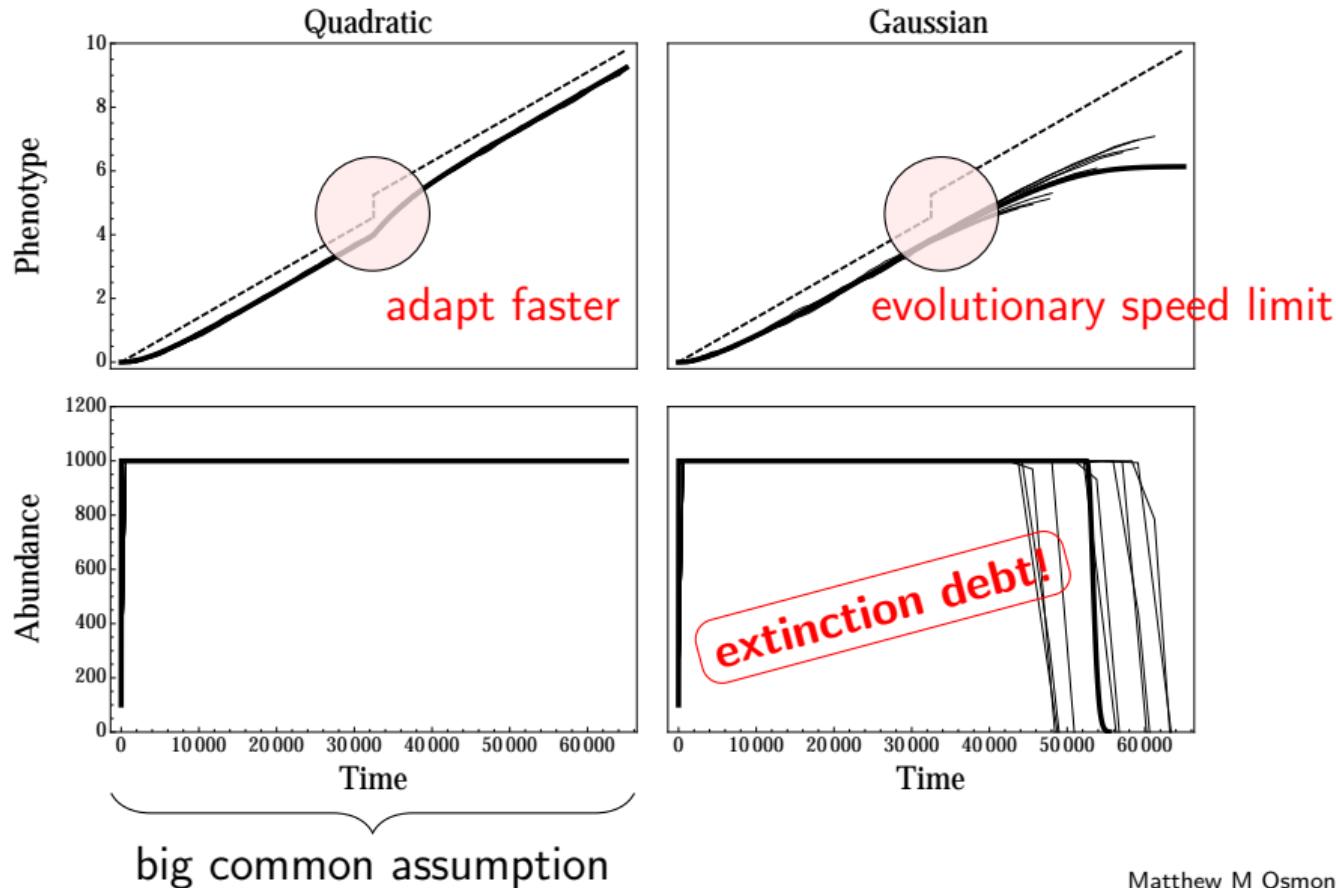
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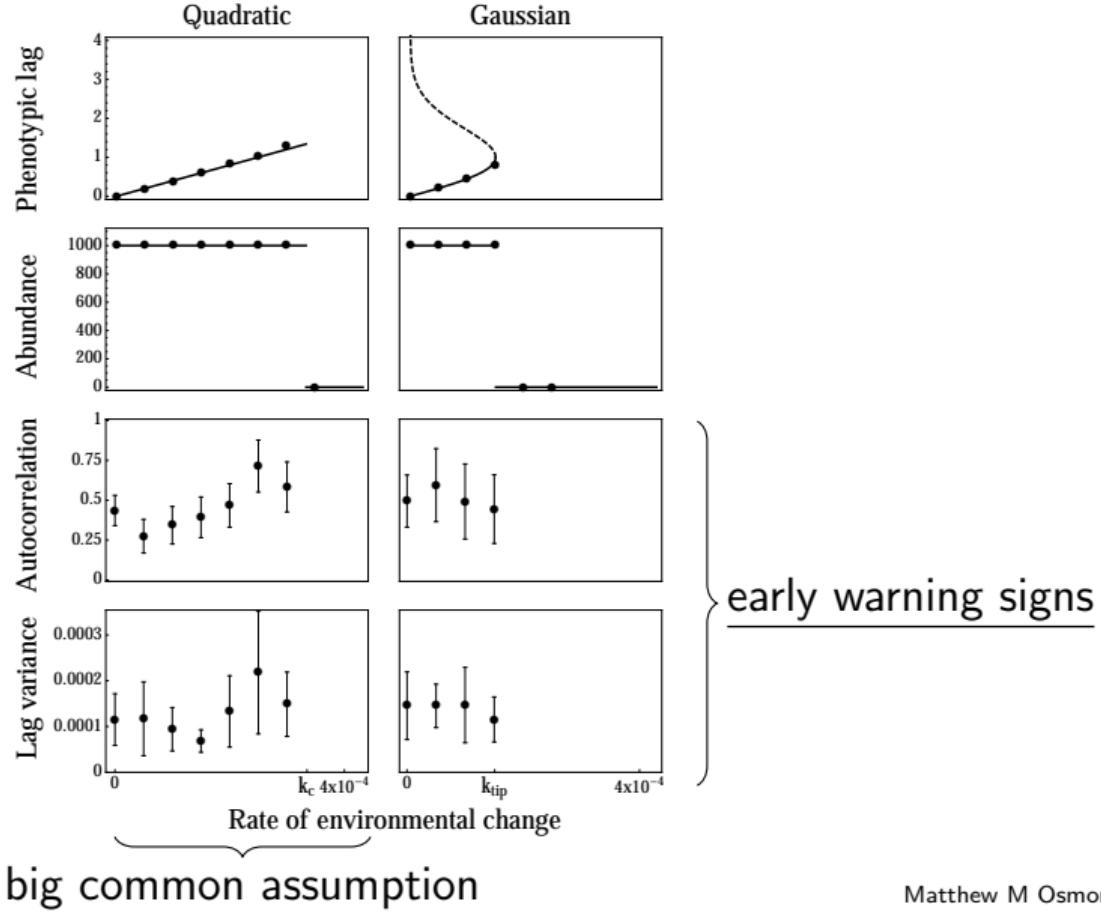
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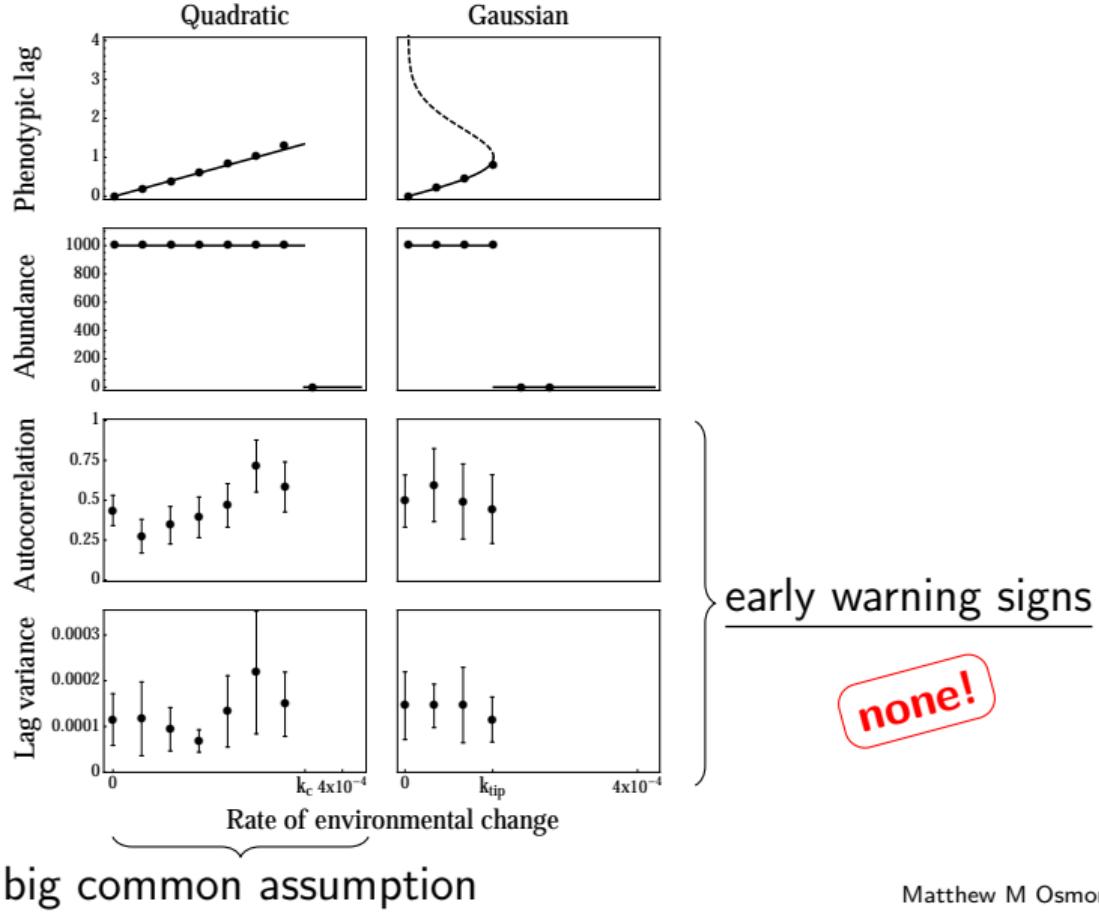
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No early warning signs of tipping point



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Take-aways

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3. small change in theory \implies drastic change in picture
4. e.g., if selection finite \implies evolutionary tipping point
5. tipping point \implies extinction debts & unexpected extinctions
6. need **more general theory** and **more data on fitness functions**

Thanks!



Sally Otto & lab



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