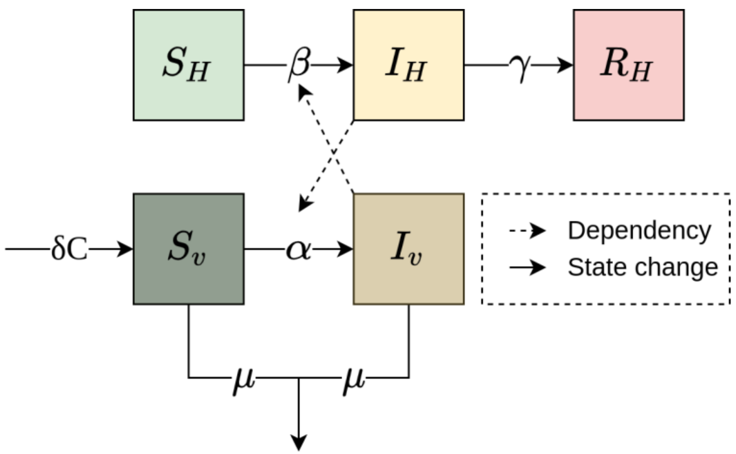
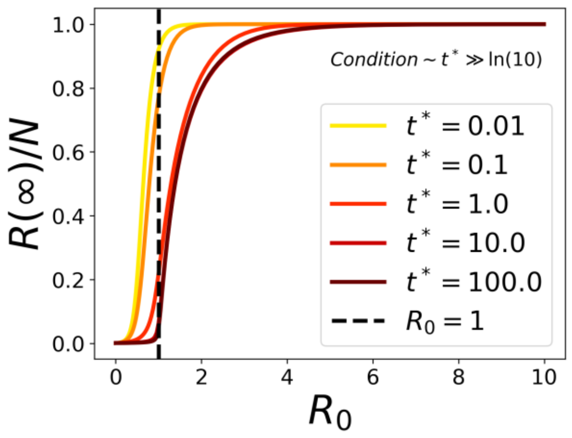
Vector-borne diseases with non-stationary vector populations: the case of growing and decaying populations

Vector-borne disease model



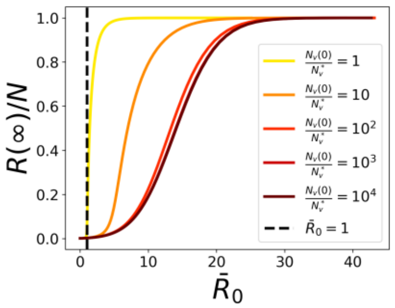
$$\dot S_H = -\beta S_H I_v/N_H$$
$$\dot I_H = \beta S_H I_v/N_H - \gamma I_H$$
$$\dot R_H = \gamma I_H$$
$$\dot S_v = \delta C - \alpha S_v I_H/N_H - \mu S_v$$
$$\dot I_v = \alpha S_v I_H/N_H - \mu I_v \ ,$$

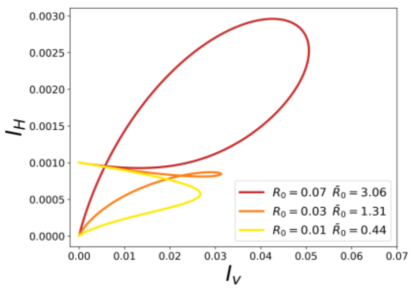
Failure of standard R_0



Extension of standard R_0

$$\overline{R_0} = \left\langle R_0^i(t) \right\rangle \Big|_0^{t_g} = \frac{R_0}{N_v^*} \left\langle N_v(t) \right\rangle \Big|_0^{t_g} = \frac{R_0}{N_v^*} \frac{1}{t_g} \int_0^{t_g} N_v(t)\,\mathrm{d}t$$





Reduction to SIR model

1) $\mu \gg \gamma \implies I_v \approx (\alpha S_v I_H)/(\mu N_H)$

$$\dot S_H = -\beta' \frac{S_H I_H}{\lambda N_H + I_H}; \quad \dot I_H = \beta' \frac{S_H I_H}{\lambda N_H + I_H} - \gamma I_H;$$

2) $\lambda N_H \gg I_H$

$$\dot S_H = -\beta_{eff} \frac{S_H I_H}{N_H}; \quad \dot I_H = \beta_{eff} \frac{S_H I_H}{N_H} - \gamma I_H;$$