

little to no diffusion  
moderate diffusion  
high diffusion

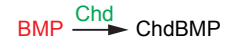
## A Model 1: Graded source-sink (mobile BMP)

$$\begin{aligned}\frac{\partial [\text{BMP}]}{\partial t} &= D_{\text{BMP}} \nabla^2 [\text{BMP}] - \kappa [\text{Chd}] [\text{BMP}] - \lambda_{\text{BMP}} [\text{BMP}] + \rho_{\text{BMP}}(x) \\ \frac{\partial [\text{Chd}]}{\partial t} &= D_{\text{Chd}} \nabla^2 [\text{Chd}] - \kappa [\text{Chd}] [\text{BMP}] - \lambda_{\text{Chd}} [\text{Chd}] \\ \frac{\partial [\text{ChdBMP}]}{\partial t} &= D_{\text{ChdBMP}} \nabla^2 [\text{ChdBMP}] + \kappa [\text{Chd}] [\text{BMP}] - \lambda_{\text{Chd}} [\text{ChdBMP}]\end{aligned}$$



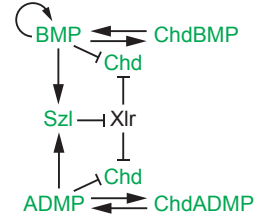
## B Model 2: Graded source-sink (immobile BMP)

$$\begin{aligned}\frac{\partial [\text{BMP}]}{\partial t} &= -\kappa [\text{Chd}] [\text{BMP}] - \lambda_{\text{BMP}} [\text{BMP}] + \rho_{\text{BMP}}(x) \\ \frac{\partial [\text{Chd}]}{\partial t} &= D_{\text{Chd}} \nabla^2 [\text{Chd}] - \kappa [\text{Chd}] [\text{BMP}] - \lambda_{\text{Chd}} [\text{Chd}] \\ \frac{\partial [\text{ChdBMP}]}{\partial t} &= D_{\text{ChdBMP}} \nabla^2 [\text{ChdBMP}] + \kappa [\text{Chd}] [\text{BMP}] - \lambda_{\text{Chd}} [\text{ChdBMP}]\end{aligned}$$



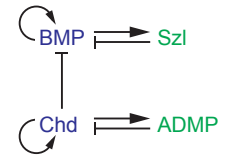
## C Model 3: Long-range accumulation and feedback

$$\begin{aligned}\frac{\partial [\text{BMP}]}{\partial t} &= D \nabla^2 [\text{BMP}] + \frac{v_{\text{BMP}} ([\text{ADMP}] + [\text{BMP}])^{10}}{k_{\text{BMP}}^{10} + ([\text{ADMP}] + [\text{BMP}])^{10}} - \lambda_{\text{BMP}} [\text{BMP}] + \frac{\lambda_{\text{Chd}} [\text{ChdBMP}]}{1 + \frac{[\text{Szl}]}{ki} + \frac{[\text{Chd}] + [\text{ChdBMP}] + [\text{ChdADMP}]}{km}} - k [\text{Chd}] [\text{BMP}] \\ \frac{\partial [\text{Chd}]}{\partial t} &= D \nabla^2 [\text{Chd}] + \frac{v_{\text{Chd}} k_{\text{Chd}}^{10}}{k_{\text{Chd}}^{10} + ([\text{ADMP}] + [\text{BMP}])^{10}} - \frac{\lambda_{\text{Chd}} [\text{Chd}]}{1 + \frac{[\text{Szl}]}{ki} + \frac{[\text{Chd}] + [\text{ChdBMP}] + [\text{ChdADMP}]}{km}} - k [\text{Chd}] [\text{BMP}] - k [\text{Chd}] [\text{ADMP}] \\ \frac{\partial [\text{ADMP}]}{\partial t} &= D \nabla^2 [\text{ADMP}] + \frac{v_{\text{ADMP}} k_{\text{ADMP}}^{10}}{k_{\text{ADMP}}^{10} + ([\text{ADMP}] + [\text{BMP}])^{10}} - \lambda_{\text{BMP}} [\text{ADMP}] + \frac{\lambda_{\text{Chd}} [\text{ChdADMP}]}{1 + \frac{[\text{Szl}]}{ki} + \frac{[\text{Chd}] + [\text{ChdBMP}] + [\text{ChdADMP}]}{km}} - k [\text{Chd}] [\text{ADMP}] \\ \frac{\partial [\text{Szl}]}{\partial t} &= D \nabla^2 [\text{Szl}] + \frac{v_{\text{Szl}} ([\text{ADMP}] + [\text{BMP}])^{20}}{k_{\text{Szl}}^{20} + ([\text{ADMP}] + [\text{BMP}])^{20}} - \lambda_{\text{Szl}} [\text{Szl}] \\ \frac{\partial [\text{ChdBMP}]}{\partial t} &= D \nabla^2 [\text{ChdBMP}] - \frac{\lambda_{\text{Chd}} [\text{ChdBMP}]}{1 + \frac{[\text{Szl}]}{ki} + \frac{[\text{Chd}] + [\text{ChdBMP}] + [\text{ChdADMP}]}{km}} + k [\text{Chd}] [\text{BMP}] \\ \frac{\partial [\text{ChdADMP}]}{\partial t} &= D \nabla^2 [\text{ChdADMP}] - \frac{\lambda_{\text{Chd}} [\text{ChdADMP}]}{1 + \frac{[\text{Szl}]}{ki} + \frac{[\text{Chd}] + [\text{ChdBMP}] + [\text{ChdADMP}]}{km}} + k [\text{Chd}] [\text{ADMP}]\end{aligned}$$



## D Model 4: Self-regulating reaction-diffusion system

$$\begin{aligned}\frac{\partial [\text{BMP}]}{\partial t} &= D_{\text{BMP}} \nabla^2 [\text{BMP}] + \frac{[\text{BMP}]^2}{(1 + [\text{Chd}][\text{Szl}])} - \mu_{\text{BMP}} [\text{BMP}] + \rho_{\text{BMP}} \\ \frac{\partial [\text{Chd}]}{\partial t} &= D_{\text{Chd}} \nabla^2 [\text{Chd}] + \frac{[\text{Chd}]^2}{[\text{ADMP}]} - \mu_{\text{Chd}} [\text{Chd}] + \rho_{\text{Chd}} \\ \frac{\partial [\text{ADMP}]}{\partial t} &= D_{\text{ADMP}} \nabla^2 [\text{ADMP}] + [\text{Chd}]^2 - \mu_{\text{ADMP}} [\text{ADMP}] \\ \frac{\partial [\text{Szl}]}{\partial t} &= D_{\text{Szl}} \nabla^2 [\text{Szl}] + [\text{BMP}]^2 - \mu_{\text{Szl}} [\text{Szl}]\end{aligned}$$



## E Model 5: Shuttling

$$\begin{aligned}\frac{\partial [\text{BMP}]}{\partial t} &= D_{\text{BMP}} \nabla^2 [\text{BMP}] - \kappa [\text{Chd}] [\text{BMP}] + \lambda [\text{Xlr}] [\text{ChdBMP}] - \lambda_{\text{BMP}} [\text{BMP}] + \rho_{\text{BMP}}(x) \\ \frac{\partial [\text{Chd}]}{\partial t} &= D_{\text{Chd}} \nabla^2 [\text{Chd}] - \kappa [\text{Chd}] [\text{BMP}] - \lambda_{\text{Chd}} [\text{Chd}] \\ \frac{\partial [\text{ChdBMP}]}{\partial t} &= D_{\text{ChdBMP}} \nabla^2 [\text{ChdBMP}] + \kappa [\text{Chd}] [\text{BMP}] - \lambda [\text{Xlr}] [\text{ChdBMP}] - \lambda_{\text{Chd}} [\text{ChdBMP}]\end{aligned}$$



Figure 1 - figure supplement 1