One patch, with and without effect of microbes on pollinators

This creates phase plane and time series plots for one-plant model with and without feedbacks between microbes and pollinators, and with low and high yeast dispersal rates (keeping bacterial dispersal rates constant). It results in the following files:

- 1 patch – h0 – dy1.1 – phase.pdf
- 1 patch – h2 – dy0.9 – timeseries.pdf
- 1 patch – h2 – dy0.9 – phase.pdf
- 1 patch – h2 – dy1.1 – timeseries.pdf
- 1 patch – h2 – dy1.1 – phase.pdf
- 1 patch – h0 – dy0.9 – timeseries.pdf
- 1 patch – h0 – dy0.9 – phase.pdf
- 1 patch – h0 – dy1.1 – timeseries.pdf

Figure 2 uses two of these files, 1 patch – h2 – dy0.9 – phase.pdf (panel c) and 1 patch – h2 – dy1.1 – phase.pdf (panel d). The rest I created to better understand the dynamics.

Load package and set working directory:

```
In[1]:=  Needs["EcoEvo`"];
         SetDirectory[NotebookDirectory[]];
         SetDirectory[ParentDirectory[] <> "/_figures/_raw-nb"];
```

Define model in EcoEvo:

```
In[4]:= SetModel[{Pop[Y] → {Equation ⧴ dy disp[B, h, S0, L0] Y (1 - Y - B) - m Y,
          Range ⧴ Interval[{0, 1}], Color → RGBColor["#FFCC33"]},
        Pop[B] → {Equation ⧴ (db0 + db disp[B, h, S0, L0]) B (1 - Y - B) - m B,
          Range ⧴ Interval[{0, 1}], Color → RGBColor["#333399"]},
        Parameters ⧴ {dy ≥ 0, db0 ≥ 0, db ≥ 0, h ≥ 0, L0 ≥ 0, m ≥ 0, S0 ≥ 0}}];
    disp[B_, h_, S0_, L0_] := Module[{P},
      P = S0^h / (S0^h + B^h);
      P / (L0 + P)
      ];
```

Create functions used throughout and define unchanging parameter values:

```
In[6]:= Pvec[S0_, h_, L0_, t_, simBFun_] = disp[simBFun[t], h, S0, L0];
    timeseriesPlot[maxt_?NumericQ, hiStart_?NumericQ, loStart_?NumericQ] :=
      Module[{sim1, sim2, simp1, simp2, p1, p2, pp1, pp2},
        sim1 = EcoSim[{Y → hiStart, B → loStart}, maxt];
        sim2 = EcoSim[{Y → loStart, B → hiStart}, maxt];
        simp1 = PlotDynamics[sim1, AxesLabel → None];
        simp2 = PlotDynamics[sim2, AxesLabel → None];
        p1 = Plot[Pvec[S0, h, L0, t, sim1〚2〛〚2〛],
          {t, 0, maxt}, PlotStyle → Directive[Thick, Gray, Dashed],
          AspectRatio → 0.85, PlotRange → {Automatic, {0, 1}}];
        p2 = Plot[Pvec[S0, h, L0, t, sim2〚2〛〚2〛],
          {t, 0, maxt}, PlotStyle → Directive[Thick, Gray, Dashed],
          AspectRatio → 0.85, PlotRange → {Automatic, {0, 1}}];
        pp1 = Show[p1, simp1, PlotRange → {Automatic, {0, 1}}, AxesOrigin → {0, 0}];
        pp2 = Show[p2, simp2, PlotRange → {Automatic, {0, 1}}, AxesOrigin → {0, 0}];
        GraphicsRow[{pp1, pp2}, ImageSize → Medium]
      ];
    db = 0.4;
    db0 = 0.3;
    m = 0.1;
    S0 = 0.4;
```
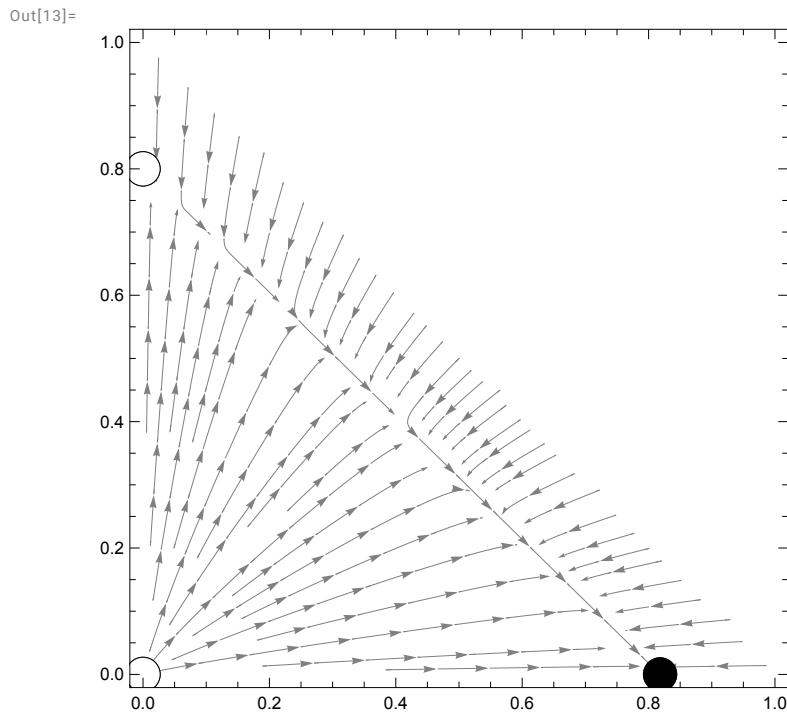
Phase planes and time series plots

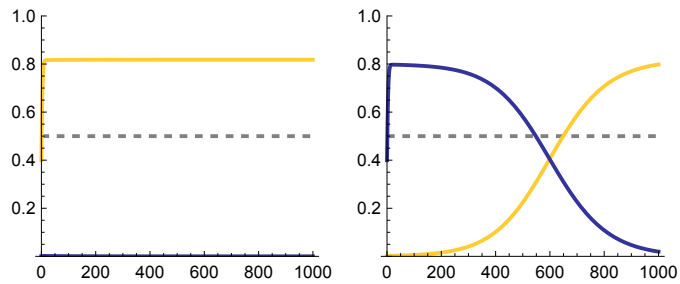## No feedbacks, high yeast dispersal

```
In[11]:= Clear[h, dy, L0];
    h = 0.0; dy = 1.1; L0 = 0.5;
    p = PlotEcoPhasePlane[ {Y, 0, 1}, {B, 0, 1},
       IsoclineStyle → {Opacity[0], Opacity[0]},
       RuleListPlotOpts → {StableMarker →
          {Graphics[{Black, Disk[{0, 0}]}, ImageSize → 20, AlignmentPoint → {0, 0}]},
         UnstableMarker → {Graphics[{EdgeForm[{Black}], FaceForm[White], Disk[{0, 0}]},
            ImageSize → 20, AlignmentPoint → {0, 0}]}},
       FrameLabel → None,
       RegionFunction → Function[{Y, B}, 0 ≤ Y + B ≤ 1]]
    Export[File["1patch-h0-dy1.1-phase.pdf"], p];
    Clear[p];
```

Out[13]=

In[16]:=
```
Clear[h, dy, L0];
h = 0.0; dy = 1.1; L0 = 0.5;
combinedPlot = timeseriesPlot[1000, 0.4, 0.001]
Export[File["1patch-h0-dy1.1-timeseries.pdf"], combinedPlot];
Clear[combinedPlot];
```
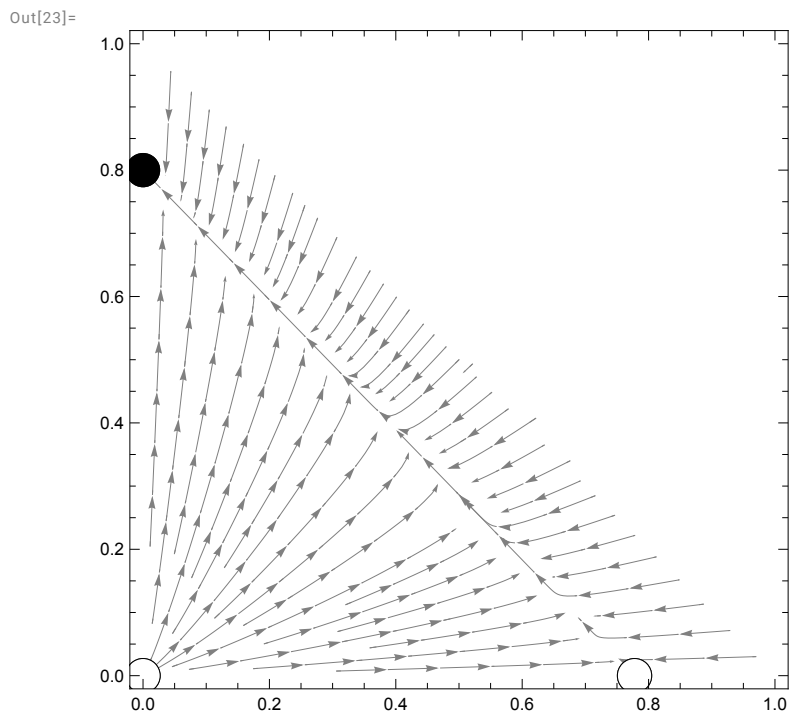
Out[18]=

No feedbacks, low yeast dispersal
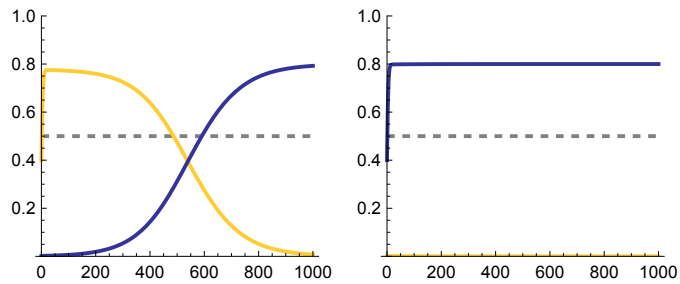
```
In[21]:= Clear[h, dy, L0];
     h = 0.0; dy = 0.9; L0 = 0.5;
     p = PlotEcoPhasePlane[ {Y, 0, 1}, {B, 0, 1},
        IsoclineStyle → {Opacity[0], Opacity[0]},
        RuleListPlotOpts → {StableMarker →
            {Graphics[{Black, Disk[{0, 0}]}, ImageSize → 20, AlignmentPoint → {0, 0}]},
          UnstableMarker → {Graphics[{EdgeForm[{Black}], FaceForm[White], Disk[{0, 0}]},
              ImageSize → 20, AlignmentPoint → {0, 0}]}},
        FrameLabel → None,
        RegionFunction → Function[{Y, B}, 0 ≤ Y + B ≤ 1]]
     Export[File["1patch-h0-dy0.9-phase.pdf"], p];
     Clear[p];
```

Out[23]=

In[26]:=
```
Clear[h, dy, L0];
h = 0.0; dy = 0.9; L0 = 0.5;
combinedPlot = timeseriesPlot[1000, 0.4, 0.001]
Export[File["1patch-h0-dy0.9-timeseries.pdf"], combinedPlot];
Clear[combinedPlot];
```
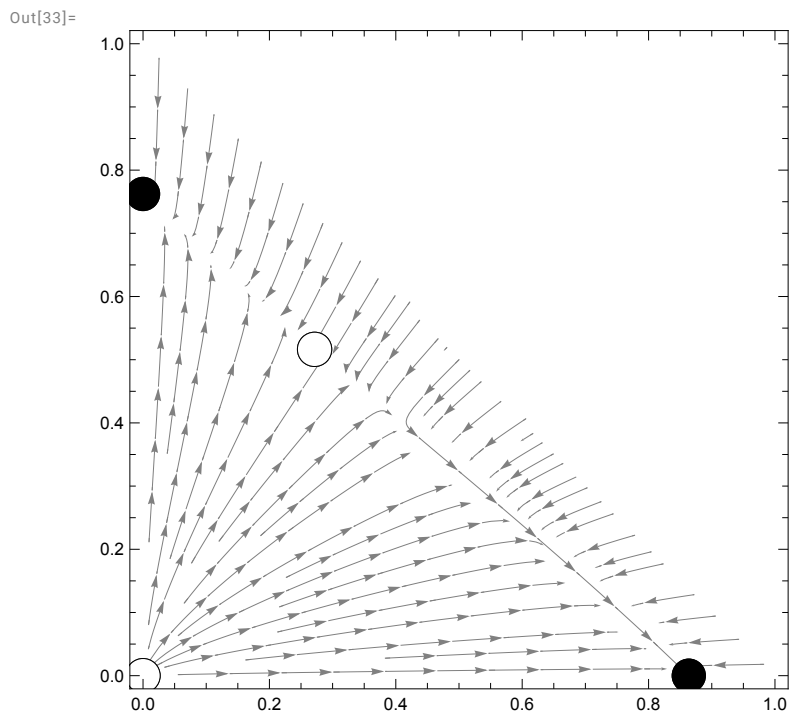
Out[28]=

With feedbacks, high yeast dispersal
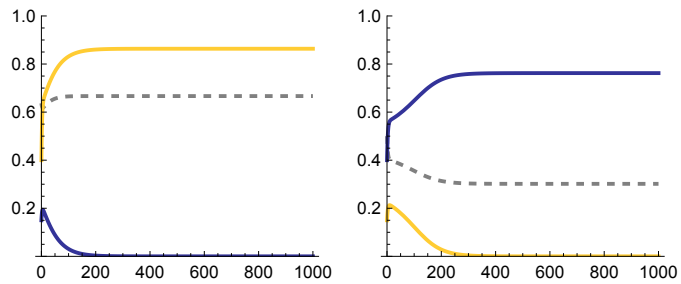
```
In[31]:= Clear[h, dy, L0];
     h = 2.0; dy = 1.1; L0 = 0.5;
     p = PlotEcoPhasePlane[ {Y, 0, 1}, {B, 0, 1},
        IsoclineStyle → {Opacity[0], Opacity[0]},
        RuleListPlotOpts → {StableMarker →
           {Graphics[{Black, Disk[{0, 0}]}, ImageSize → 20, AlignmentPoint → {0, 0}]},
          UnstableMarker → {Graphics[{EdgeForm[{Black}], FaceForm[White], Disk[{0, 0}]},
             ImageSize → 20, AlignmentPoint → {0, 0}]}},
        FrameLabel → None,
        RegionFunction → Function[{Y, B}, 0 ≤ Y + B ≤ 1]]
     Export[File["1patch-h2-dy1.1-phase.pdf"], p];
     Clear[p];
```

Out[33]=

In[36]:= `Clear[h, dy, L0];`
`h = 2.0; dy = 1.1; L0 = 0.5;`
`combinedPlot = timeseriesPlot[1000, 0.4, 0.15]`
`Export[File["1patch-h2-dy1.1-timeseries.pdf"], combinedPlot];`
`Clear[combinedPlot];`

Out[38]=

With feedbacks, low yeast dispersal

```
In[41]:= Clear[h, dy, L0];
      h = 2.0; dy = 0.9; L0 = 0.5;
      p = PlotEcoPhasePlane[ {Y, 0, 1}, {B, 0, 1},
        IsoclineStyle → {Opacity[0], Opacity[0]},
        RuleListPlotOpts → {StableMarker →
          {Graphics[{Black, Disk[{0, 0}]}, ImageSize → 20, AlignmentPoint → {0, 0}]},
         UnstableMarker → {Graphics[{EdgeForm[{Black}], FaceForm[White], Disk[{0, 0}]},
            ImageSize → 20, AlignmentPoint → {0, 0}]}},
        FrameLabel → None,
        RegionFunction → Function[{Y, B}, 0 ≤ Y + B ≤ 1]]
      Export[File["1patch-h2-dy0.9-phase.pdf"], p];
      Clear[p];
```

Out[43]=
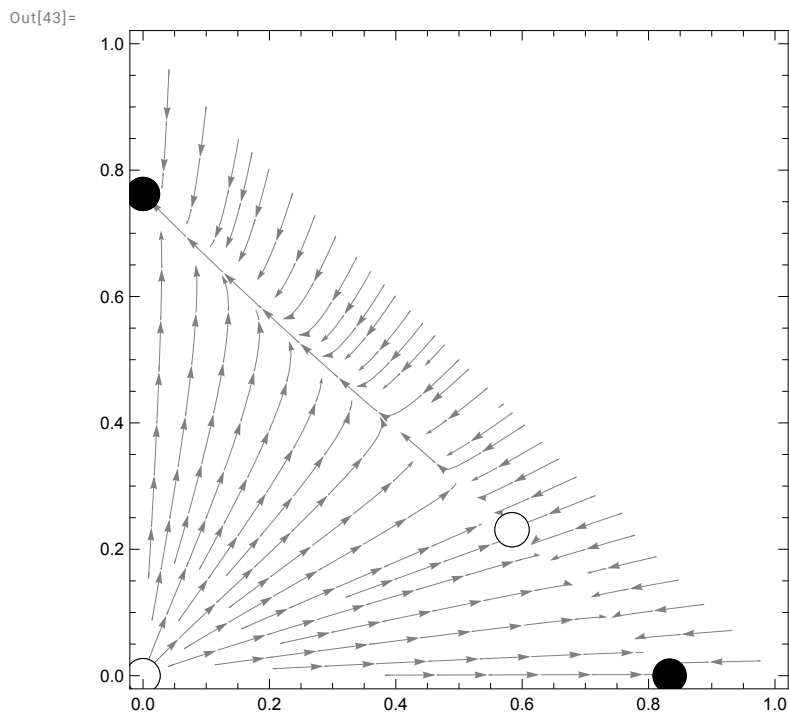
In[46]:= `Clear[h, dy, L0];`
`h = 2.0; dy = 0.9; L0 = 0.5;`
`combinedPlot = timeseriesPlot[1000, 0.4, 0.15]`
`Export[File["1patch-h2-dy0.9-timeseries.pdf"], combinedPlot];`
`Clear[combinedPlot];`

Out[48]=