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%4-Cup Dispersal w/ LPA Model
%adding direct cost to dispersal

b = 20;
mu_a = 0.0842;
mu_l = 0.6053;
c_ea = 0.0179;
c_el = 0.0003;
c_pa = 0.0;
gammaR = 0.3; % chance of adult leaving any patch
gammaM = 0.1; % chance of mutant adult leaving any patch
Eps = 0.1; % chance of adult dying from dispersal
k = 4;

MaxT = 20;

DF1i = zeros(MaxT,12);
DF1i(1,1) = 67;
DF1i(1,5) = 26;
DF1i(1,9) = 236;

DF2i = zeros(MaxT,12);
DF2i(1,1) = 0;
DF2i(1,5) = 0;
DF2i(1,9) = 0;

DF3i = zeros(MaxT,12);
DF3i(1,1) = 0;
DF3i(1,5) = 0;
DF3i(1,9) = 0;

DF4i = zeros(MaxT,12);
DF4i(1,1) = 0;
DF4i(1,5) = 0;
DF4i(1,9) = 0;

for i = 1:MaxT
    %PATCH 1
    DF1i(i+1,1)= b*DF1i(i,9)*exp(-c_ea*(sum(DF1i(i,2*k+1:3*k))-c_el*(sum(DF1i(i,1:1*k)))));
    DF1i(i+1,2)= b*DF1i(i,10)*exp(-c_ea*(sum(DF1i(i,2*k+1:3*k))-c_el*(sum(DF1i(i,1:1*k)))));
    DF1i(i+1,3)= b*DF1i(i,11)*exp(-c_ea*(sum(DF1i(i,2*k+1:3*k))-c_el*(sum(DF1i(i,1:1*k)))));
    DF1i(i+1,4)= b*DF1i(i,12)*exp(-c_ea*(sum(DF1i(i,2*k+1:3*k))-c_el*(sum(DF1i(i,1:1*k)))));

    DF1i(i+1,5)= (1-mu_l)*(DF1i(i,2));
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    DF1i(i+1,6)= (1-mu_l)*(DF1i(i,3));
    DF1i(i+1,7)= (1-mu_l)*(DF1i(i,4));
    DF1i(i+1,8)= (1-mu_l)*(DF1i(i,5));

    DF1i(i+1,9) =
DF1i(i,5)*exp(-c_pa*(sum(DF1i(i,2*k+1:3*k))))+((1-mu_a)*(1-gammaR))*DF1i(i,9)+1/2*(sum(DF2
i(i,2*k+1:3*k))+sum(DF3i(i,2*k+1:3*k)))*gammaR*(1-mu_a)*(1-Eps);
    DF1i(i+1,10) =
DF1i(i,6)*exp(-c_pa*(sum(DF1i(i,2*k+1:3*k))))+((1-mu_a)*(1-gammaR))*DF1i(i,10)+1/2*(sum(DF
2i(i,2*k+1:3*k))+sum(DF3i(i,2*k+1:3*k)))*gammaR*(1-mu_a)*(1-Eps);
    DF1i(i+1,11) =
DF1i(i,7)*exp(-c_pa*(sum(DF1i(i,2*k+1:3*k))))+((1-mu_a)*(1-gammaR))*DF1i(i,11)+1/2*(sum(DF
2i(i,2*k+1:3*k))+sum(DF3i(i,2*k+1:3*k)))*gammaR*(1-mu_a)*(1-Eps);
    DF1i(i+1,12) =
DF1i(i,8)*exp(-c_pa*(sum(DF1i(i,2*k+1:3*k))))+((1-mu_a)*(1-gammaR))*DF1i(i,12)+1/2*(sum(DF
2i(i,2*k+1:3*k))+sum(DF3i(i,2*k+1:3*k)))*gammaR*(1-mu_a)*(1-Eps);

    %PATCH 2
    DF2i(i+1,1)= b*DF2i(i,9)*exp(-c_ea*(sum(DF2i(i,2*k+1:3*k))-c_el*(sum(DF2i(i,1:1*k)))));
    DF2i(i+1,2)= b*DF2i(i,10)*exp(-c_ea*(sum(DF2i(i,2*k+1:3*k))-c_el*(sum(DF2i(i,1:1*k)))));
    DF2i(i+1,3)= b*DF2i(i,11)*exp(-c_ea*(sum(DF2i(i,2*k+1:3*k))-c_el*(sum(DF2i(i,1:1*k)))));
    DF2i(i+1,4)= b*DF2i(i,12)*exp(-c_ea*(sum(DF2i(i,2*k+1:3*k))-c_el*(sum(DF2i(i,1:1*k)))));

    DF2i(i+1,5)= (1-mu_l)*(DF2i(i,2));
    DF2i(i+1,6)= (1-mu_l)*(DF2i(i,3));
    DF2i(i+1,7)= (1-mu_l)*(DF2i(i,4));
    DF2i(i+1,8)= (1-mu_l)*(DF2i(i,5));

    DF2i(i+1,9) =
DF2i(i,5)*exp(-c_pa*(sum(DF2i(i,2*k+1:3*k))))+((1-mu_a)*(1-gammaR))*DF2i(i,9)+1/2*(sum(DF1
i(i,2*k+1:3*k))+sum(DF4i(i,2*k+1:3*k)))*gammaR*(1-mu_a)*(1-Eps);
    DF2i(i+1,10) =
DF2i(i,6)*exp(-c_pa*(sum(DF2i(i,2*k+1:3*k))))+((1-mu_a)*(1-gammaR))*DF2i(i,10)+1/2*(sum(DF
1i(i,2*k+1:3*k))+sum(DF4i(i,2*k+1:3*k)))*gammaR*(1-mu_a)*(1-Eps);
    DF2i(i+1,11) =
DF2i(i,7)*exp(-c_pa*(sum(DF2i(i,2*k+1:3*k))))+((1-mu_a)*(1-gammaR))*DF2i(i,11)+1/2*(sum(DF
1i(i,2*k+1:3*k))+sum(DF4i(i,2*k+1:3*k)))*gammaR*(1-mu_a)*(1-Eps);
    DF2i(i+1,12) =
DF2i(i,8)*exp(-c_pa*(sum(DF2i(i,2*k+1:3*k))))+((1-mu_a)*(1-gammaR))*DF2i(i,12)+1/2*(sum(DF
1i(i,2*k+1:3*k))+sum(DF4i(i,2*k+1:3*k)))*gammaR*(1-mu_a)*(1-Eps);

    %PATCH 3
    DF3i(i+1,1)= b*DF3i(i,9)*exp(-c_ea*(sum(DF3i(i,2*k+1:3*k))-c_el*(sum(DF3i(i,1:1*k)))));
    DF3i(i+1,2)= b*DF3i(i,10)*exp(-c_ea*(sum(DF3i(i,2*k+1:3*k))-c_el*(sum(DF3i(i,1:1*k)))));
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DF3i(i+1,3)= b*DF3i(i,11)*exp(-c_ea*(sum(DF3i(i,2*k+1:3*k))-c_el*(sum(DF3i(i,1:1*k)))));
DF3i(i+1,4)= b*DF3i(i,12)*exp(-c_ea*(sum(DF3i(i,2*k+1:3*k))-c_el*(sum(DF3i(i,1:1*k)))));

DF3i(i+1,5)= (1-mu_l)*(DF3i(i,2));
DF3i(i+1,6)= (1-mu_l)*(DF3i(i,3));
DF3i(i+1,7)= (1-mu_l)*(DF3i(i,4));
DF3i(i+1,8)= (1-mu_l)*(DF3i(i,5));

DF3i(i+1,9) =
DF3i(i,5)*exp(-c_pa*(sum(DF3i(i,2*k+1:3*k))))+((1-mu_a)*(1-gammaR))*DF3i(i,9)+1/2*(sum(DF1
i(i,2*k+1:3*k))+sum(DF4i(i,2*k+1:3*k)))*gammaR*(1-mu_a)*(1-Eps);
DF3i(i+1,10) =
DF3i(i,6)*exp(-c_pa*(sum(DF3i(i,2*k+1:3*k))))+((1-mu_a)*(1-gammaR))*DF3i(i,10)+1/2*(sum(DF
1i(i,2*k+1:3*k))+sum(DF4i(i,2*k+1:3*k)))*gammaR*(1-mu_a)*(1-Eps);
DF3i(i+1,11) =
DF3i(i,7)*exp(-c_pa*(sum(DF3i(i,2*k+1:3*k))))+((1-mu_a)*(1-gammaR))*DF3i(i,11)+1/2*(sum(DF
1i(i,2*k+1:3*k))+sum(DF4i(i,2*k+1:3*k)))*gammaR*(1-mu_a)*(1-Eps);
DF3i(i+1,12) =
DF3i(i,8)*exp(-c_pa*(sum(DF3i(i,2*k+1:3*k))))+((1-mu_a)*(1-gammaR))*DF3i(i,12)+1/2*(sum(DF
1i(i,2*k+1:3*k))+sum(DF4i(i,2*k+1:3*k)))*gammaR*(1-mu_a)*(1-Eps);

%PATCH 4
DF4i(i+1,1)= b*DF4i(i,9)*exp(-c_ea*(sum(DF4i(i,2*k+1:3*k))-c_el*(sum(DF4i(i,1:1*k)))));
DF4i(i+1,2)= b*DF4i(i,10)*exp(-c_ea*(sum(DF4i(i,2*k+1:3*k))-c_el*(sum(DF4i(i,1:1*k)))));
DF4i(i+1,3)= b*DF4i(i,11)*exp(-c_ea*(sum(DF4i(i,2*k+1:3*k))-c_el*(sum(DF4i(i,1:1*k)))));
DF4i(i+1,4)= b*DF4i(i,12)*exp(-c_ea*(sum(DF4i(i,2*k+1:3*k))-c_el*(sum(DF4i(i,1:1*k)))));

DF4i(i+1,5)= (1-mu_l)*(DF4i(i,2));
DF4i(i+1,6)= (1-mu_l)*(DF4i(i,3));
DF4i(i+1,7)= (1-mu_l)*(DF4i(i,4));
DF4i(i+1,8)= (1-mu_l)*(DF4i(i,5));

DF4i(i+1,9) =
DF4i(i,5)*exp(-c_pa*(sum(DF4i(i,2*k+1:3*k))))+((1-mu_a)*(1-gammaR))*DF4i(i,9)+1/2*(sum(DF2
i(i,2*k+1:3*k))+sum(DF3i(i,2*k+1:3*k)))*gammaR*(1-mu_a)*(1-Eps);
DF4i(i+1,10) =
DF4i(i,6)*exp(-c_pa*(sum(DF4i(i,2*k+1:3*k))))+((1-mu_a)*(1-gammaR))*DF4i(i,10)+1/2*(sum(DF
2i(i,2*k+1:3*k))+sum(DF3i(i,2*k+1:3*k)))*gammaR*(1-mu_a)*(1-Eps);
DF4i(i+1,11) =
DF4i(i,7)*exp(-c_pa*(sum(DF4i(i,2*k+1:3*k))))+((1-mu_a)*(1-gammaR))*DF4i(i,11)+1/2*(sum(DF
2i(i,2*k+1:3*k))+sum(DF3i(i,2*k+1:3*k)))*gammaR*(1-mu_a)*(1-Eps);
DF4i(i+1,12) =
DF4i(i,8)*exp(-c_pa*(sum(DF4i(i,2*k+1:3*k))))+((1-mu_a)*(1-gammaR))*DF4i(i,12)+1/2*(sum(DF
2i(i,2*k+1:3*k))+sum(DF3i(i,2*k+1:3*k)))*gammaR*(1-mu_a)*(1-Eps);
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```matlab
end

%PATCH 1
x = linspace(1,MaxT+1,MaxT+1);
Lr = DF1i(:,1);
plot(x,Lr, linewidth=2)

hold on
Lm1 = DF1i(:,2);
plot(x,Lm1,linewidth=2)
Lm2 = DF1i(:,3);
plot(x,Lm2,linewidth=2)
Lm3 = DF1i(:,4);
plot(x,Lm3,linewidth=2)

Pr = DF1i(:,5);
plot(x,Pr, linewidth=2)

Pm1 = DF1i(:,6);
plot(x,Pm1,linewidth=2)
Pm2 = DF1i(:,7);
plot(x,Pm2,linewidth=2)
Pm3 = DF1i(:,8);
plot(x,Pm3,linewidth=2)

Ar = DF1i(:,9);
plot(x,Ar, linewidth=2)
%
% Am1 = DF1i(:,10);
% plot(x,Am1,linewidth=2)
% Am2 = DF1i(:,11);
% plot(x,Am2,linewidth=2)
% Am3 = DF1i(:,12);
% plot(x,Am3,linewidth=2)
% hold off
% lgnd =
legend('Larvae','Pupae','Adults','Larvae','Pupae','Adults','Larvae','Pupae','Adults','Larvae','Pupae','Adults');

%PATCH 2
% xr = linspace(1,MaxT+1,MaxT+1);
% yr = DF1i(:,1);
% plot(xr,yr, linewidth=2)
```

```
%
% hold on
% xm1 = linspace(1,MaxT+1,MaxT+1);
% ym1 = DF1i(:,5);
% plot(xm1,ym1,linewidth=2)
% hold off
%
% %PATCH 3
% xr = linspace(1,MaxT+1,MaxT+1);
% yr = DF1i(:,1);
% plot(xr,yr, linewidth=2)
%
% hold on
% xm1 = linspace(1,MaxT+1,MaxT+1);
% ym1 = DF1i(:,5);
% plot(xm1,ym1,linewidth=2)
% hold off
%
% %PATCH 4
% xr = linspace(1,MaxT+1,MaxT+1);
% yr = DF1i(:,1);
% plot(xr,yr, linewidth=2)
%
% hold on
% xm1 = linspace(1,MaxT+1,MaxT+1);
% ym1 = DF1i(:,5);
% plot(xm1,ym1,linewidth=2)
% hold off
```