where σ_l denotes the overwintering success of the larval population; $L_{if,t}(t_f)$ is the number of larvae that became infected in year t; and $L_{uf,t}(t_f)$ are the fed larvae that did not acquire *B. burgdorferi* in year t. The complex functions for $\hat{L}_{i,t}$ and $\hat{L}_{u,t}$ determine the total questing infected and uninfected nymphs in the following season. $N_{if,t}(t_f) + N_{uf,t}(t_f)$ describes the density of nymphs that have successfully fed by the end of year t. The complex function for $\hat{N}_t$ determines the total questing larval population the following season with σ_n accounting for both the expected fecundity per fed nymph and overwintering mortality. Adult ticks are not explicitly modeled in the preliminary analyses.

Host parameters v_h and μ_h denote birth and death rates independent of infection status. In the preliminary analyses, host birth rate is controlled by a carry capacity (k), although host dynamics will be considered in future models. Hosts acquire *B. burgdorferi* when fed upon by an infected nymph (β_{nh}). The tick bite rate (γ_n) is constant and follows mass action dynamics across all hosts. All hosts are assumed to be equally competent reservoirs and there is no incubation period between infection and infectiousness. Each of these assumptions can be modified in future analyses to address specific hypotheses about the impact of host populations on transmission dynamics. All models will be rigorously assessed by analytical and numerical methods. All iterations of the models will be compared to continuous time ODE models to specifically assess impact of phenology on transmission dynamics.

Preliminary Analyses. We parameterized the preliminary model to assess both within-season and long-term *B. burgdorferi* population dynamics. The preliminary analyses used highly-simplified assumptions that will be relaxed in future analyses. In these analyses, the within-season dynamics and inter-year dynamics are stable and reach a non-trivial equilibrium (negative, real eigenvalues) in many areas of the parameter space (Fig. 5). The within-year transmission dynamics and the resulting increase or decrease in nymphal infection prevalence (NIP) or density of infected ticks (with respect to the prior year) is strongly determined by parameter values for previously identified factors such as host-tick contact rates (γ_l; γ_n); the tick-to-host (β_{nh}) and host-to-tick transmission rates (β_{hl}); and host and tick mortality rates (μ_h, μ_l, μ_n). For example, increased contact rates (γ_l and γ_n) result in increased densities of infected ticks but not

| | Broad | | Larval activity width(λ_l) | | | | | Narrow |
	0.6	0.8	1.0	1.2	1.4	1.6	1.8	2.0
-10	19%	3%	0%	0%	0%	0%	0%	0%
-5	51%	25%	8%	4%	2%	1%	1%	0%
0	65%	60%	49%	34%	20%	12%	8%	5%
5	63%	67%	68%	67%	66%	63%	60%	56%
10	58%	63%	66%	67%	68%	69%	69%	70%
15	52%	57%	60%	62%	63%	64%	65%	66%
20	47%	51%	54%	56%	57%	58%	59%	60%
25	42%	46%	49%	50%	52%	53%	54%	54%
30	37%	41%	44%	45%	46%	47%	48%	49%
35	33%	36%	39%	40%	41%	42%	43%	43%
40	28%	32%	34%	35%	37%	37%	38%	39%
45	24%	27%	30%	31%	32%	33%	33%	34%

(Larval offset in days (ε_l) — row labels)

Fig. 5 - A non-zero nymphal infection prevalence (NIP) occurs across a broad range of seasonal distribution patterns. We varied the number of days between the emergence of nymphs and larvae (ε_l) as well as the breadth of the distribution of activity of each stage (λ). *B. burgdorferi* has the greatest success (darkest blue) at intermediate degrees of asynchrony (ε_l=10) although wider larval activity distributions allow transmission success even when the onset of larval activity proceeds that nymphs (ε_l=–10). Interestingly, large degrees of asynchrony (ε_l>15) combined with broader larval activity distributions decrease transmission success as infected hosts tend to die prior to the larval activity.
Parameter values used in Fig 5 & 6:γ_l=0.01;γ_n=0.02; μ_h=0.015;μ_l=μ_n=0.006; σ_l=σ_n=σ_h=1; β_{hl}=β_{nh}=0.8; v_h=1; ϕ_n=ϕ_l=10;$L_{t=0}$=1000; k=200; $H_{t=0}$=200 (100 *infected*).

| | Larval offset (ε_l) in Year t | | | | | | | | | |
	0	5	10	15	20	25	30	35	40	45
0	0	-12	-11	-7	-3	0	3	5	7	8
5	13	0	2	6	10	13	16	18	19	20
10	12	-2	0	4	8	12	15	17	19	20
15	8	-6	-4	0	4	8	11	14	15	17
20	4	-11	-9	-4	0	4	7	10	12	13
25	0	-15	-13	-8	-4	0	3	6	9	10
30	-3	-19	-17	-12	-7	-3	0	3	6	7
35	-7	-22	-20	-15	-11	-7	-3	0	3	5
40	-10	-26	-23	-19	-14	-10	-6	-3	0	2
45	-12	-29	-26	-22	-17	-13	-9	-5	-2	0

(Larval offset (ε_l) in Year $t+1$ — row labels)

Fig. 6 - Changes in tick stage seasonal activity can cause detectable changes in nymphal infection prevalence (NIP) the following year. Presented is the expected change from the equilibrium NIP one year after the larval offset value is altered. For example, shifting the onset of larval activity 5 days (ε_l=5) from synchronous (ε_l=0) increases NIP by from 49% to 62% (+13% in yellow box); the new equilibrium (68%) is not reached for several years. (λ_n=λ_l=1).

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