**Lab 9: Predator-Prey Stella Modeling - Instructions**

**PREDATOR MODEL 1:**

$$^{dV}/\_{dt}=b\_{v}V-d\_{v}V$$

* **PredModel1 - Step-by-step instructions**
	+ Look at document “Lab 9 Description for PredModel1 through 4,” PredModel 1 – Exponential growth of prey
	+ GOAL: Model of prey exponential growth
	+ Make sure you are on the Model tab
	+ Create a stock for the victims (prey)
		- Label: “Prey stock”
	+ Create input flow (click and drag flow ending inside box – box will be highlighted)
		- Label “Prey births”
		- Inputs will be added from stock **automatically**
		- Units are numbers per time
	+ Create output flow (click and drag starting inside box)
		- Label “Prey deaths”
		- Outputs will be subtracted from stock **automatically**
		- Units are numbers per time
	+ Create converter for prey birth rate
		- Label “Prey birth rate”
	+ Create converter for prey death rate
		- Label “Prey death rate”
	+ Make connections for inflows (point arrow tip inside converter or stock and drag):
		- Connect Prey birth rate to Prey births
		- Connect Prey stock to Prey births
	+ Make connections for outflows (point arrow tip inside converter or stock and drag):
		- Connect Prey death rate to Prey deaths
		- Connect Prey stock to Prey deaths
	+ Parameterize model! (use values in lab manual) – double click on what you want to populate
		- Prey stock abundance = 4
		- Prey birth rate = 0.80 [*note: using bmax in handout*]
		- Prey death rate = 0.05
	+ Build in equations
		- Note: Can click on item names in box above (not case sensitive; underscores are important)
		- Inflow: *bvV* (“Prey\_birth\_rate \* Prey\_stock”)
		- Outflow: *dvV* (“Prey\_death\_rate \* Prey\_stock”)
	+ Model Notes:
		- Useful model for looking at just prey dynamics
		- E.g., effects of constant proportional harvest (just increase prey death rate)
	+ Set simulation parameters (go to Run menu, Run specs)
		- Use 100 time steps [to: 100]
		- Set time step (dt) = 1 [DT: 1]
		- Set integration method to Runge-Kutta 4
	+ Add graph to model (click on Graph Pad icon)
		- Specify graph to output Prey stock (double click on graph)
		- Select “Prey\_stock” to move over (>>)
		- Click tack icon to pin
	+ Add table to model (click on Table Pad icon)
		- Specify table to output Prey stock
		- Select “Prey\_stock” to move over (>>)
		- Click tack icon to pin
		- Can grab vertical line to draw out column width
	+ Run model (watch the flow!)
		- **The numbers are going to look weird b/c using data that works for final model**
		- Prey exponential growth
	+ **Save model as: PredModel1.stm**

**PREDATOR MODEL 2:**

MODIFY to include density dependence: $^{dV}/\_{dt}=b\_{max}\left(1-\frac{V}{K}\right)V-d\_{v}V$

* **PredModel2 - Step-by-step instructions**
	+ Look at document “Lab 9 Description for PredModel1 through 4,” PredModel2 – density dependence of prey
	+ GOAL: Add density dependence to prey birth rate function
	+ Make new converters
		- “Prey max birth rate”
		- “Prey carrying capacity”
	+ Make connections to Prey birth rate converter:
		- Connect Prey stock to Prey birth rate
		- Connect Prey max birth rate to Prey birth rate
		- Connect Prey carrying capacity to Prey birth rate
	+ Parameterize model
		- Prey max birth rate = 0.80
		- Prey carrying capacity = 20
	+ Specify logistic equation in birth rate converter
		- Remove constant
		- Birth rate is now a function of three parameters: V, K, bmax
		- Prey\_max\_birth\_rate \* (1 – (Prey\_stock / Prey\_carrying\_capacity))
	+ Run model
		- Density dependent prey growth to K growth
	+ **Save model as: PredModel2.stm**

**PREDATOR MODEL 3:**

MODIFY to include predation: $^{dV}/\_{dt}=b\_{max}\left(1-\frac{V}{K}\right)V-d\_{v}V-aVP$

ADD: $^{dP}/\_{dt}=acVP-d\_{p}P$

* **PredModel3 - Step-by-step instructions**
	+ Look at document “Lab 9 Description for PredModel1 through 4,” PredModel3
	+ GOAL: Add predator!
	+ Highlight all prey boxes and arrow (click and drag box over space) and move down
	+ Create predator stock
		- Label: “Predator stock”
	+ Create inflows and outflows
		- Inflow: “Predator births”
		- Outflow: “Predator deaths”
	+ Add converters to inflow
		- “Conversion efficiency”
		- “Attack rate” 🡪 put by prey
	+ Make connections for inflow
		- Connect Conversion efficiency to Predator births
		- Connect Attack rate to Predator births
		- Connect Predator stock to Predator births
		- Connect Prey stock to Predator births
	+ Add converter to outflow
		- “Predator death rate”
	+ Make connections to outflow
		- Connect Predator death rate to Predator deaths
		- Connect Predator stock to Predator deaths
	+ Modify prey
		- Connect Attack rate to Prey deaths
		- Connect Predator stock to Prey deaths
	+ Parameterize model
		- Predator stock abundance = 2
		- Conversion efficiency = 0.60
		- Predator death rate = 0.60
		- Attack rate = 0.10
	+ Specify Predator births equation
		- Predator births are a function of: Attack rate, Conversion efficiency, Prey stock, and Predator stock: *acVP*
		- Attack\_rate \* Conversion\_efficiency \* Prey\_stock \* Predator\_stock
	+ Specify Predator deaths equation
		- *dpP*
		- Predator\_death\_rate \* Predator\_stock
	+ Re-specify Prey deaths equation
		- Prey deaths occur through two ways! *dvV + aVP*
		- KEEP: Prey\_death\_rate \* Prey\_stock
		- ADD: + Attack\_rate \* Prey\_stock \* Predator\_stock
		- We add the new term (not subtract) because the sum will be subtracted from stock
	+ Change graph output
		- Output Predator stock, too
		- Select “Predator\_stock” to move over (>>)
	+ Change table output
		- Output Predator stock, too
		- Select “Predator\_stock” to move over (>>)
	+ Run simulation
		- Predator-prey fluctuations then level to equilibrium
	+ **Save model as: PredModel3.stm**

**PREDATOR MODEL 4:**

KEEP: $^{dV}/\_{dt}=b\_{max}\left(1-\frac{V}{K}\right)V-d\_{v}V-aVP$

KEEP: $^{dP}/\_{dt}=acVP-d\_{p}P$

ADD: via qualifying statement: PREDATOR TERRITORIALITY

* **PredModel4 - Step-by-step instructions**
	+ GOAL: Add predator territoriality
	+ Create converter for predator ceiling (Look at document “Lab 9 Description for PredModel1 through 4,” PredModel4)
		- Label: “Predator ceiling”
		- i.e., a ceiling for the predator population beyond which it will not increase, no matter how productive the prey are
	+ Create connection
		- Connect Predator ceiling to Predator births
	+ Parameterize model
		- Ceiling = 100 🡪 Scramble predator
		- Ceiling = 5 🡪 Contest predator (highly territorial – only 5 territories)
	+ Re-specify Predator births
		- IF(Predator\_stock < Predator\_ceiling) THEN (Attack\_rate \* Conversion\_efficiency \* Prey\_stock \* Predator\_stock) ELSE (0)
		- Means that if predator stock is below ceiling, predator births are a function of the usual: *acVP*, otherwise, births are zero (and population will fall below predator ceiling)
	+ Run simulation
		- Predator-prey fluctuations then level to equilibrium
	+ **Save model as: PredModel4.stm**

**🡪 Over to PowerPoint**