



Combining System Dynamics and Structured Decision Making for Chronic Wasting Disease Policy

Practitioner Application Report

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Abstract

Chronic Wasting Disease (CWD) is a fatal prion disease affecting white-tailed deer and other cervids. It now affects a number of US states. Management of the disease is complex, due to spatial heterogeneity, diverse stakeholder interests, and limited agency resources. This work describes the use of a System Dynamics model to support the update of Wisconsin's 15-year CWD management plan. Following Structured Decision Making methodology, stakeholders generated alternative actions and metrics of interest. Simulations, automated in Python, mapped the effects of each action package on their metrics, providing visual and quantitative summaries of performance along each dimension. Stakeholders could then weight outcomes according to their preferred metrics. Inclusion of the model in the stakeholder process provided a consistent structure for discussion and focused effort on important leverage points.

Chronic Wasting Disease Policy

- **Client: Wisconsin DNR via USGS NWHC**
- **Question: how best to use agency resources to reduce the prevalence and geographic spread of CWD?**
- **Stakeholders: hunters, landowners, captive cervid farmers, wildlife NGOs, waste disposal industry, tribes, other agencies ...**
- **Process:**
 - Structured Decision Making (essentially, stakeholder identification of metrics of interest and ranking of alternative actions' influence on each outcome)
 - Supported by SD modeling: model informs action->metric mapping

Chronic Wasting Disease

- **Prion disease, like Mad Cow and scrapie**
- **Affects cervids (deer family)**
- **100% fatal**
- **Long latent period, short clinical phase**
- **Environmental reservoir**
- **No human transmission ...yet**



Why do we need new approaches for CWD?

WHAT YOU CAN DO TO SLOW THE SPREAD OF CWD

TEST THE DEER YOU HARVEST

CWD testing is free, accurate and helpful for disease monitoring efforts.

After registering a deer, hunters anywhere in Wisconsin can submit a sample - the deer's head with three inches of neck attached - for testing as soon as possible after harvest.

When submitting a sample, hunters should provide the following information:

- » Deer harvest authorization number
- » DNR customer number
- » Contact information for test results
- » Location of harvest (county, township, range, section and quarter section)

Test results are typically available 10-14 days after the deer is brought to a sampling station.

For more information and to find sampling locations, visit dnr.wi.gov and search "CWD sampling."

TRANSPORT AND DISPOSE OF DEER CARCASSES PROPERLY

Healthy deer may contract CWD through exposure to contaminated soil where a CWD-positive carcass has decomposed. That's why disposing of deer carcasses properly, including bones and butchering waste, helps slow the spread of CWD.

- » Use processors and taxidermists who dispose of deer waste in a landfill.
- » Keep deer carcasses within the county of harvest or an immediately adjacent county.
- » Do not bring a deer carcass from a state/province that has CWD into Wisconsin unless it is taken directly to a meat processor or taxidermist within 72 hours of entry into the state.
- » For non-resident hunters, consult your home state's website or regulations book for information on deer carcass import requirements.

For more information and locations, visit dnr.wi.gov and search "carcass disposal."

PARTICIPATE IN ADOPT-A-KIOSK AND ADOPT-A-DUMPSTER

Providing access to sampling and proper carcass disposal helps hunters slow the spread of CWD.

Individuals or organizations can support hunters and deer herd health in their area by sponsoring a kiosk or carcass disposal dumpster through the Adopt-a-Kiosk and Adopt-a-Dumpster programs.

To learn more, visit dnr.wi.gov, search keyword "CWD" and click on the Adopt-a-Kiosk and Adopt-a-Dumpster links under the Volunteer section.

REPORT A SICK DEER

Reporting sick deer is an efficient way to monitor deer herd health throughout the year. Anyone who observes a sick deer is encouraged to report their sighting to the DNR.

To find local DNR staff, visit dnr.wi.gov and search "sick deer."

KNOW ABOUT BAITING AND FEEDING

More than half of Wisconsin's 72 counties have active bans on baiting and feeding deer because of the risk of CWD transmission when animals gather in unnaturally high densities.

One way hunters and wildlife watchers can help slow the spread is by adhering to bans where they are in effect and by choosing not to bait or feed in counties without a ban.

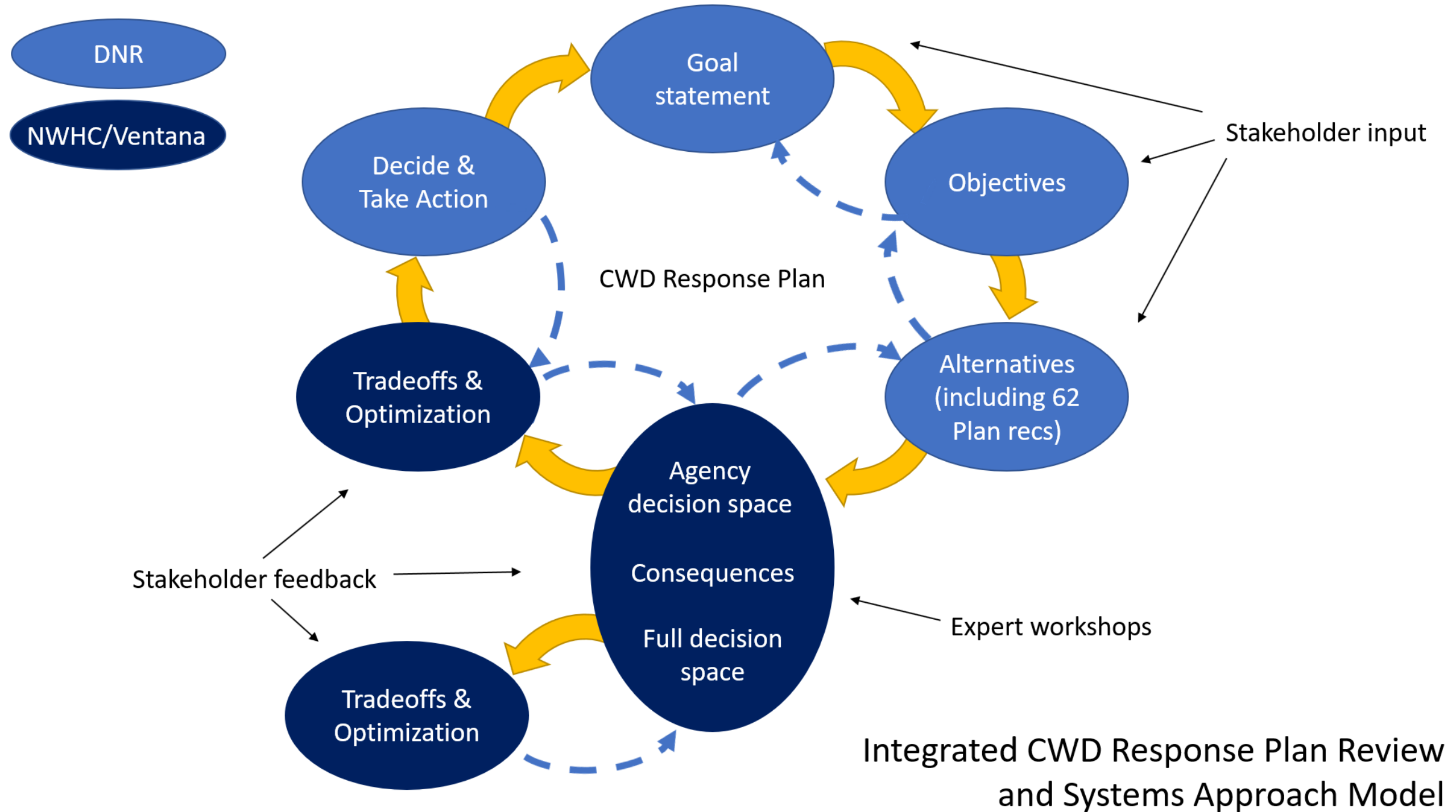
For hunters using scent lures, consider the following recommendations:

- » Use commercially produced scent-wicks that can be hung from a twig or branch and then removed at the end of the hunt.
- » Use scents in re-sealable containers to prevent contact with soil and vegetation.
- » Switch to synthetic or food-based scents and eliminate the use of urine-based scents.

For more information, visit dnr.wi.gov and search "baiting and feeding."

- **Current actions are not controlling the prevalence and spread of CWD**
- **Success Requires:**
 - New strategies
 - New authorities
 - New stakeholders
 - New thinking

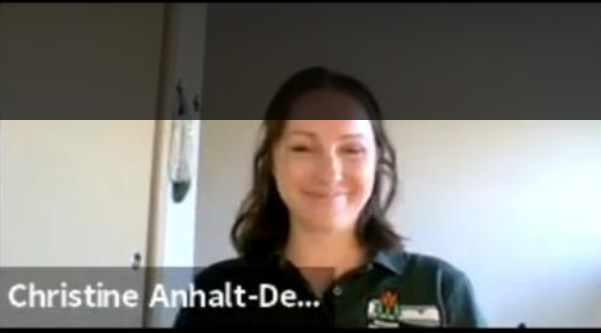




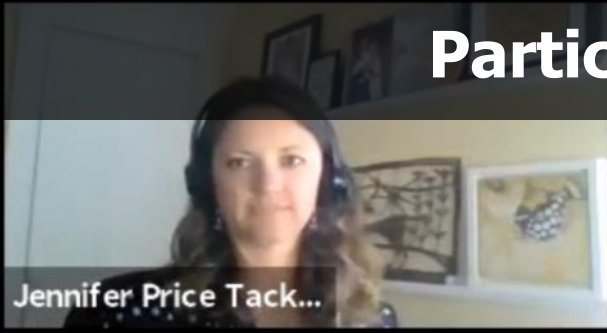
Phase 1 Approach

- **Situation**
 - Limited time and fixed schedule for stakeholder interactions
 - Heavy demands for scenario evaluation
 - Good precedent models in the literature
 - But large uncertainty about some features
- **Strategy**
 - No formal maximum likelihood calibration
 - Calibrate very loosely to replicate the range of disease prevalence growth rates observed in minimally-controlled situations
 - Establish parameters primarily from literature and subject matter experts
 - Develop notional uncertainties from:
 - Subject matter experts
 - Disagreement in the literature
 - Experimentation with face validity of model results
 - Limited calibration experiments with MCMC
 - Considerable use of data to describe behaviors seen in the model

Participants



Christine Anhalt-De...



Jennifer Price Tack...



Curt Rollman, WI D...



Tami Ryan, WI DNR

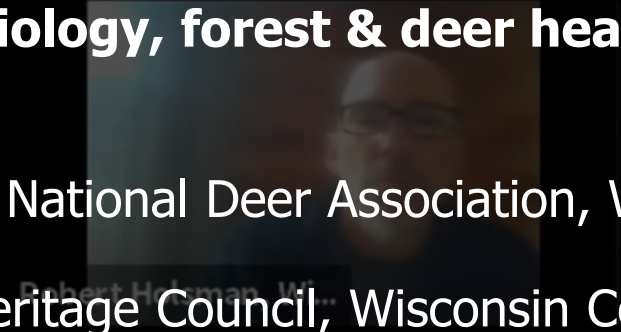
- **Model Elicitation – 5 panels covering epidemiology, forest & deer health, human dimensions, regulatory structure and integration**
- **Stakeholder Review**
 - Hunting NGOs – Wisconsin Wildlife Federation, National Deer Association, Wisconsin Bowhunters, Backcountry Hunters & Anglers
 - Policy NGOs – Wisconsin Greenfire, Sporting Heritage Council, Wisconsin Conservation Congress
 - Business interests – WI Counties Solid Waste Management Assoc., WI Commercial Deer & Elk Farmers Assoc., Whitetails of Wisconsin
 - Tribal interests – Oneida Nation, Great Lakes Indian Fish & Wildlife Comm., Red Cliff Band of Lake Superior Chippewa
 - Agencies – Wisconsin DNR, DATCP, DHS & Veterinary Diagnostics Lab., USDA



Jeff Pritzl, WI DNR



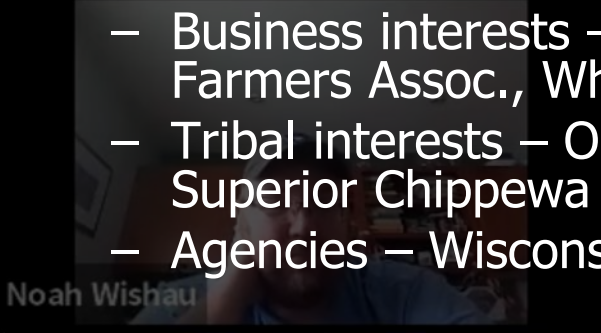
Amanda Kamps, DN



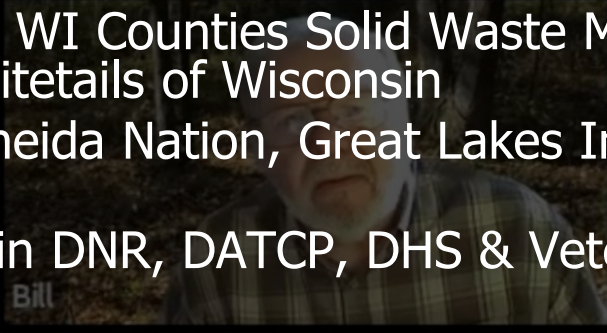
Robert Holman, WI...



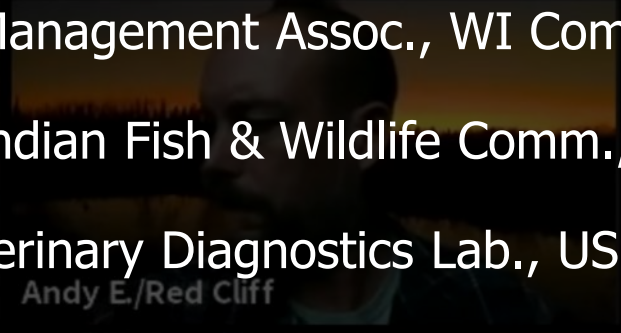
Mike Savan...



Noah Wishau



Bill



Andy E./Red Cliff



Dan Tyrolt



Sarah Wyrick



Kip Adams



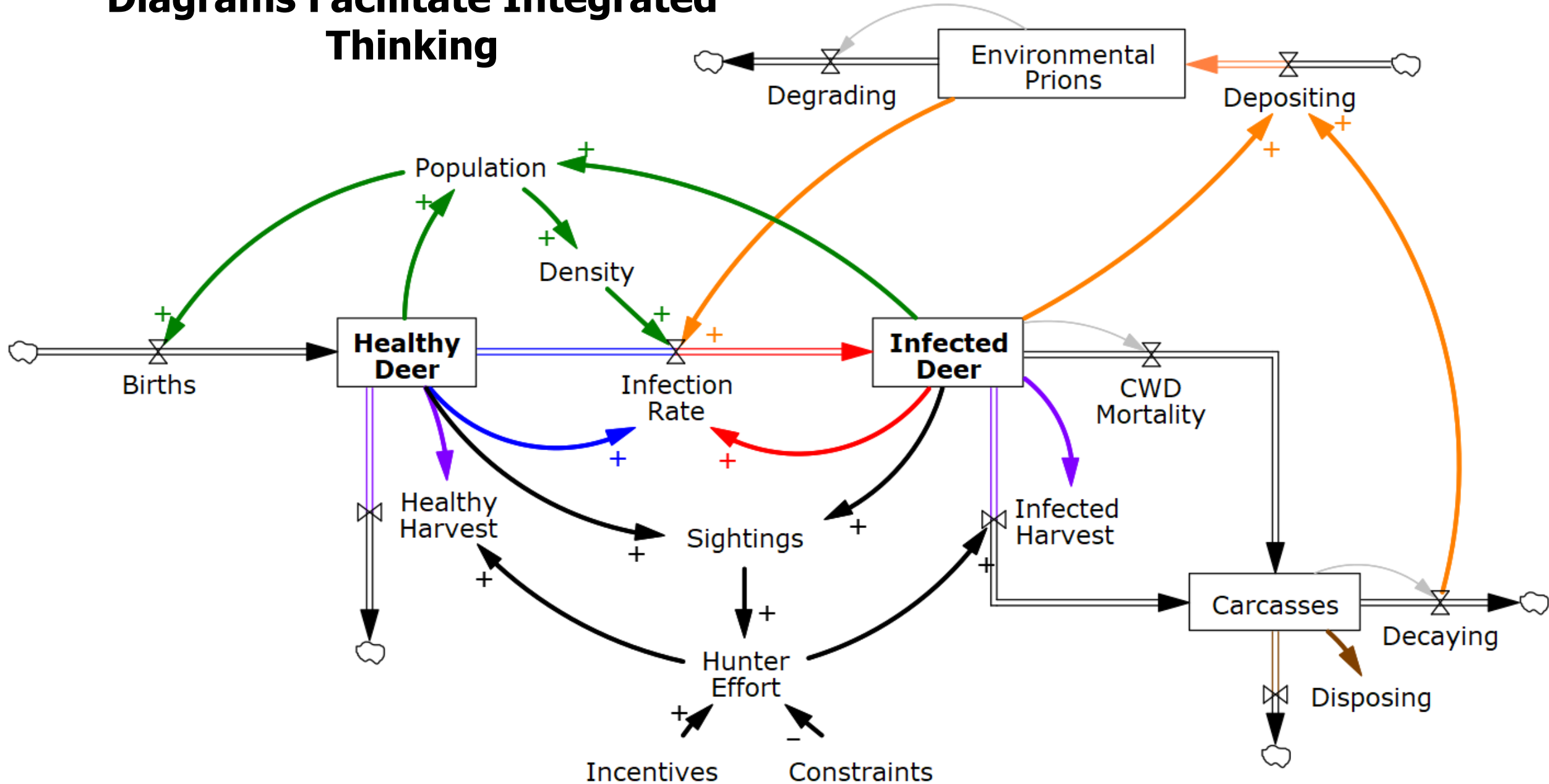
Ryan Rodenkirch



Mike



Diagrams Facilitate Integrated Thinking



Just a Few Uncertainties...

Density dependence of infection transmission

Baiting & feeding effect size

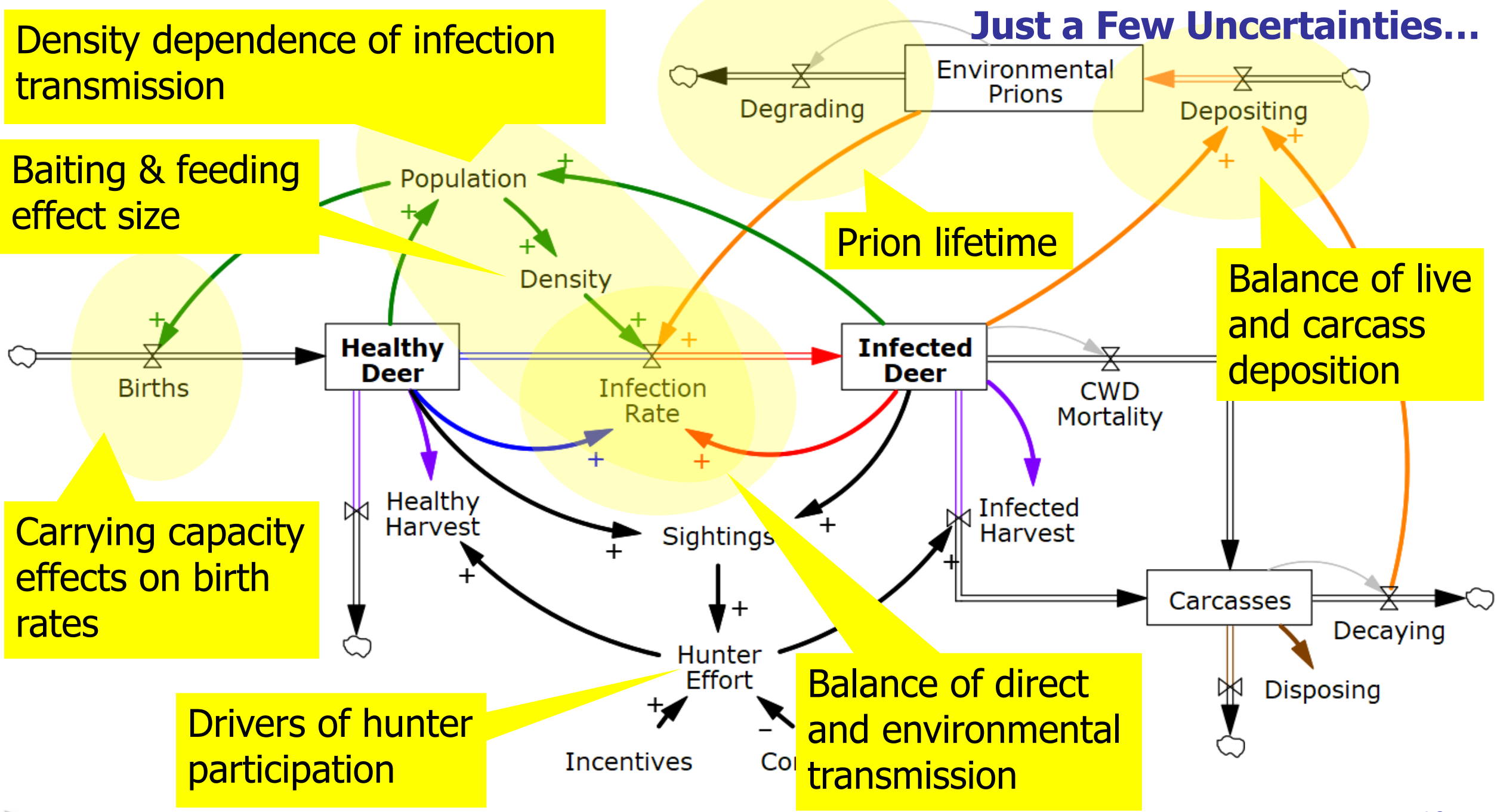
Carrying capacity effects on birth rates

Drivers of hunter participation

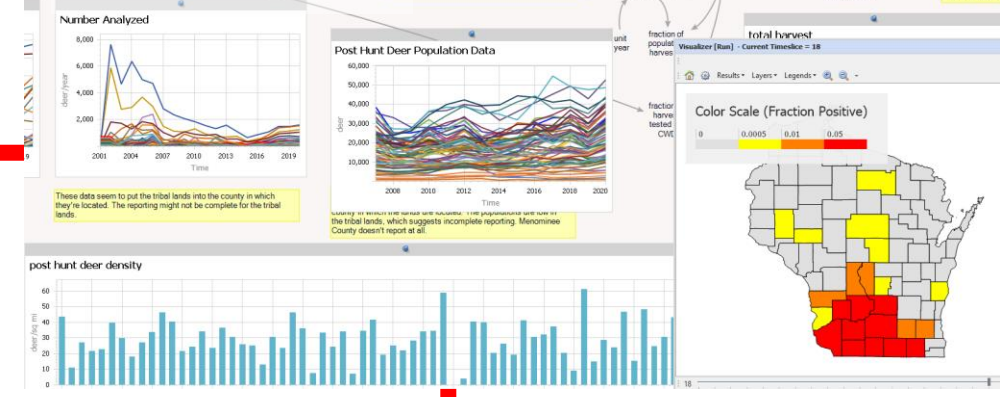
Balance of direct and environmental transmission

Prion lifetime

Balance of live and carcass deposition



Data Model



Process

Driving Data

Parameters + Uncertainty

- CWD transmission
- Environmental prions
- Deer fertility & mortality

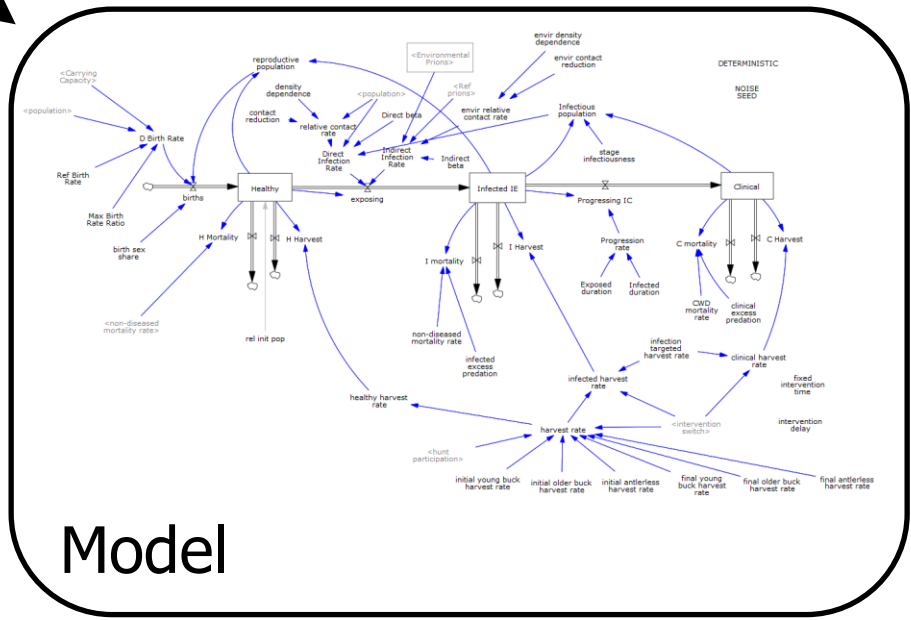
Decisions

- Hunting
- Baiting & feeding
- Surveillance
- Carcass management
- Safe practices
- Timing

Comparisons

Outcomes

- + **Uncertainty**
- Prevalence
- Fraction positive
- Population
- Age, sex structure
- Harvest
- Surveillance results
- Hunt effort
- Human exposure

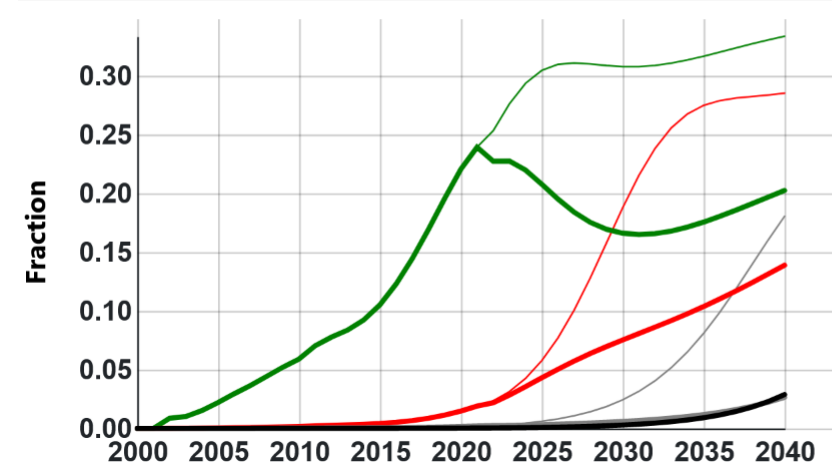


Interactivity Allowed Stakeholders to Suggest Experiments

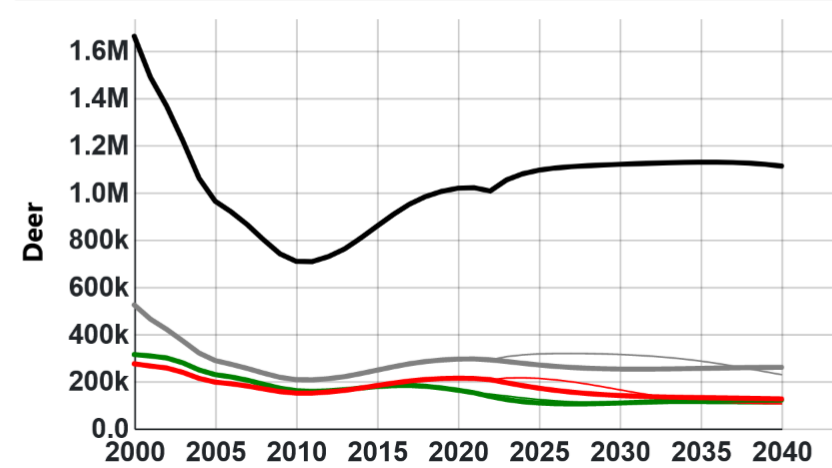


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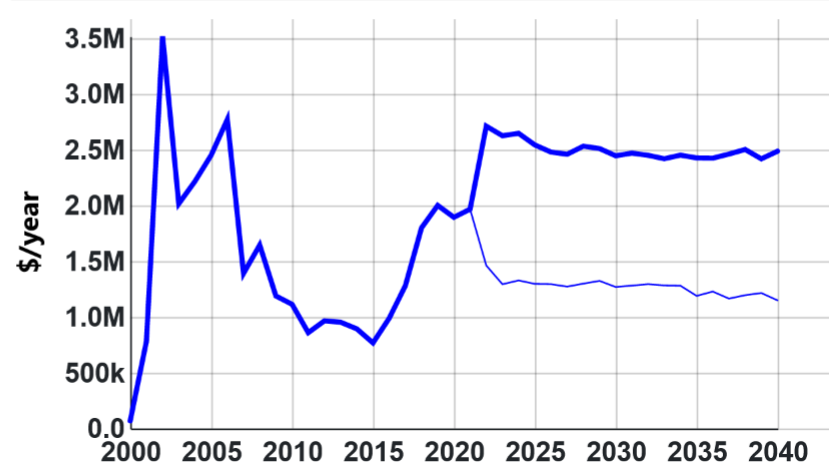
Fraction Positive



Healthy Population



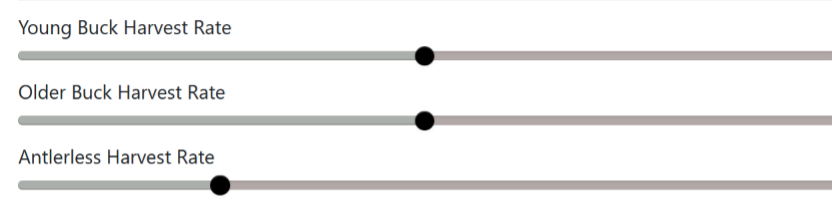
Agency Expenses



- Baseline
- Baseline-Endemic
- Baseline-Leading
- Baseline-New
- Baseline-Undetected
- User
- User-Endemic
- User-Leading
- User-New
- User-Undetected

Statewide Endemic Leading Edge New Foci Undetected

Harvest



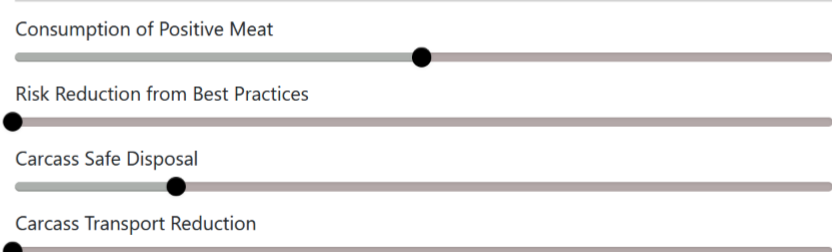
Sharpshooting



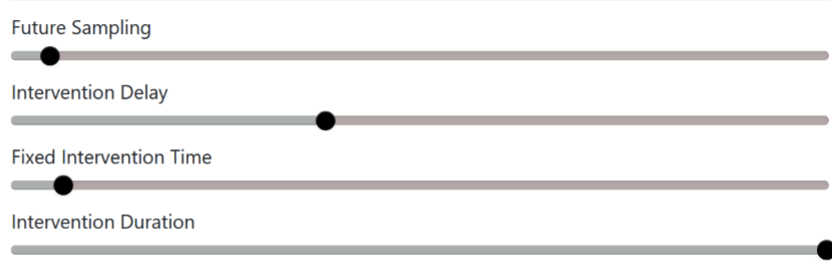
Baiting & Feeding



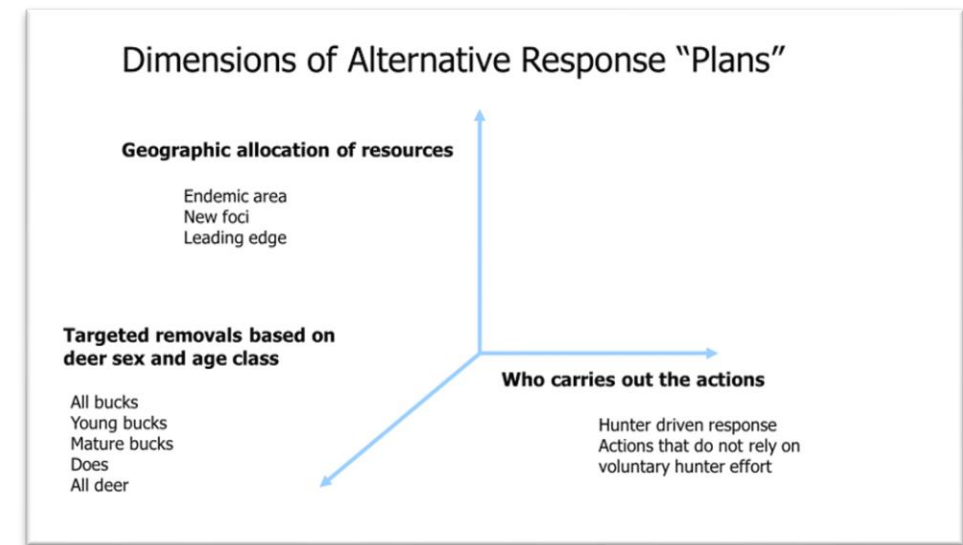
Safe Practices



Surveillance



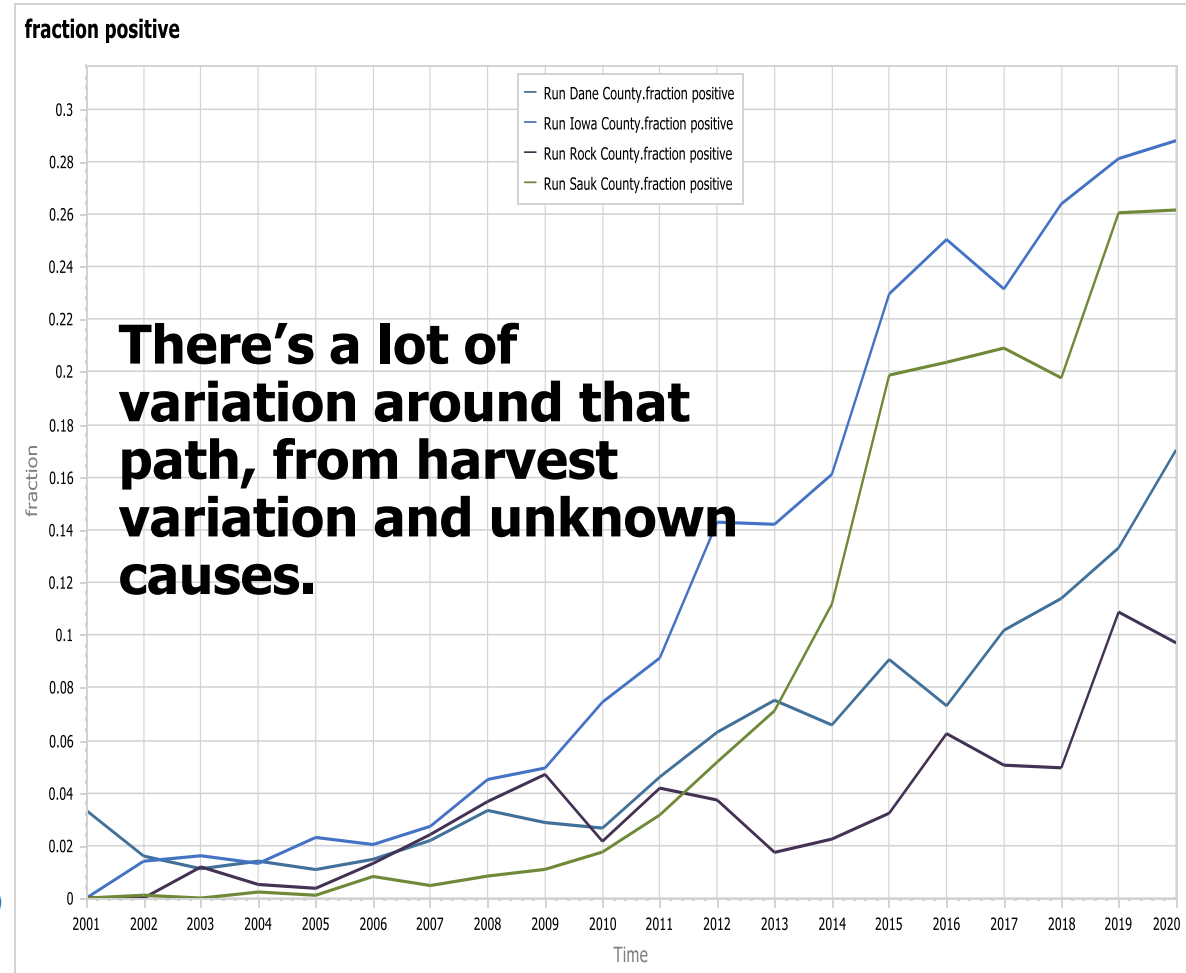
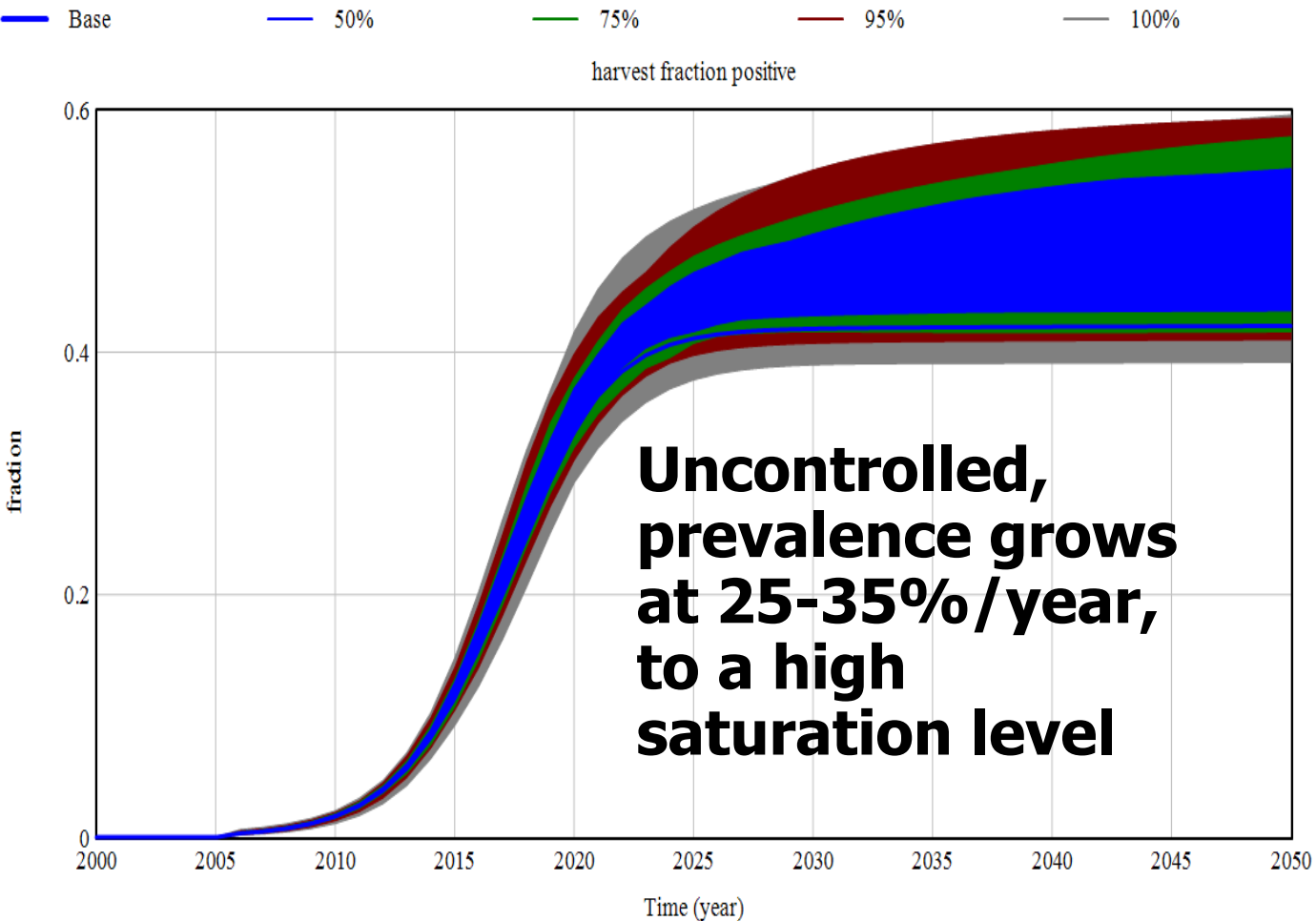
Consequence Tables Summarize Outcomes for Multiple Strategies



Harvest Action

Row Labels	Base	Uniform	Antlerless	Older Bucks	All Bucks	Perfect Targeting
population	871	376	379	875	879	778
older buck population	154	53	86	117	98	118
healthy population	456	269	214	505	554	569
prevalence	0.48	0.29	0.44	0.42	0.37	0.27
harvest fraction positive	0.46	0.28	0.39	0.44	0.38	0.37
positive harvest consumed	74	31	36	76	74	61
clinical prevalence	0.02	0.02	0.02	0.02	0.02	0.02
total harvest	255	185	150	280	314	271
trophy harvest	46	26	26	58	49	47
relative harvest effort	0.96	1.60	1.38	1.09	1.24	1.19
Vegetation Index	1.02	1.09	1.08	1.02	1.02	1.04

Monte Carlo Simulations & Data Capture Uncertainty



Phase 1 Challenges

- **Difficult to assess: possible reticence of stakeholders who didn't buy into the modeling process**
- **Missed opportunities:**
 - Characterizing the historical trajectory – what did policies achieve?
 - Exploring counterfactual histories – where would we be with no control effort?
 - Challenging past mistakes
 - Density-dependent transmission and bathtub dynamics
- **Shortcomings:**
 - The baseline, frequency dependent simulation makes control too hard – discouraging?
 - Limited characterization of uncertainty of results



Project Wins to Date

Products	Insights	Buy-in
<ul style="list-style-type: none">• Integration of SDM and System Dynamics Models• Evaluated management alternatives to inform planning• Illuminating key CWD processes affected by proposed management— including feedbacks, system delays, social “short-circuiting”• Example of the benefit of systems modeling when applied to wildlife health	<ul style="list-style-type: none">• Arresting CWD growth requires large reductions in CWD transmission (~50-80%)• Success unlikely to be achieved by a single intervention → multiple intensive and sustained approaches required• Modest reallocation of current resources will not have a large effect• Historical policies discontinued may have had substantial benefits• There are lots of cognitive bias traps	<ul style="list-style-type: none">• Participatory workshops created buy-in from stakeholders and increased credibility for the agency• Productive conversations with stakeholders, because the model served as a focal point for discussion and resolved conflicts• Enhanced WDNR’s current processes

Thanks!

Supplemental

Selected “discoveries” for modelers and stakeholders

- **It’s difficult to achieve control with existing policies**
- **There are multiple places to intervene**
- **Early intervention is much more effective**
- **Historical policies probably helped avoid a worse situation today**
- **Key elements of response plans have not been implemented**
- **Counties are too large for effective targeting**
- **Counties are too small for effective management of geographic spillovers**
- **Declining hunting can mask population effects from CWD**
- **Long time-to-discovery implies substantial undiscovered infected areas**
- **Offsetting sampling biases make true prevalence different from apparent fraction positive**
- **Sightings of clinically sick deer are expected to be rare**
- **Surveillance doesn’t do anything unless you follow up on positive discoveries**
- **Uncertainties = opportunities**

Sample Insights about the 2012 Deer Trustee Report

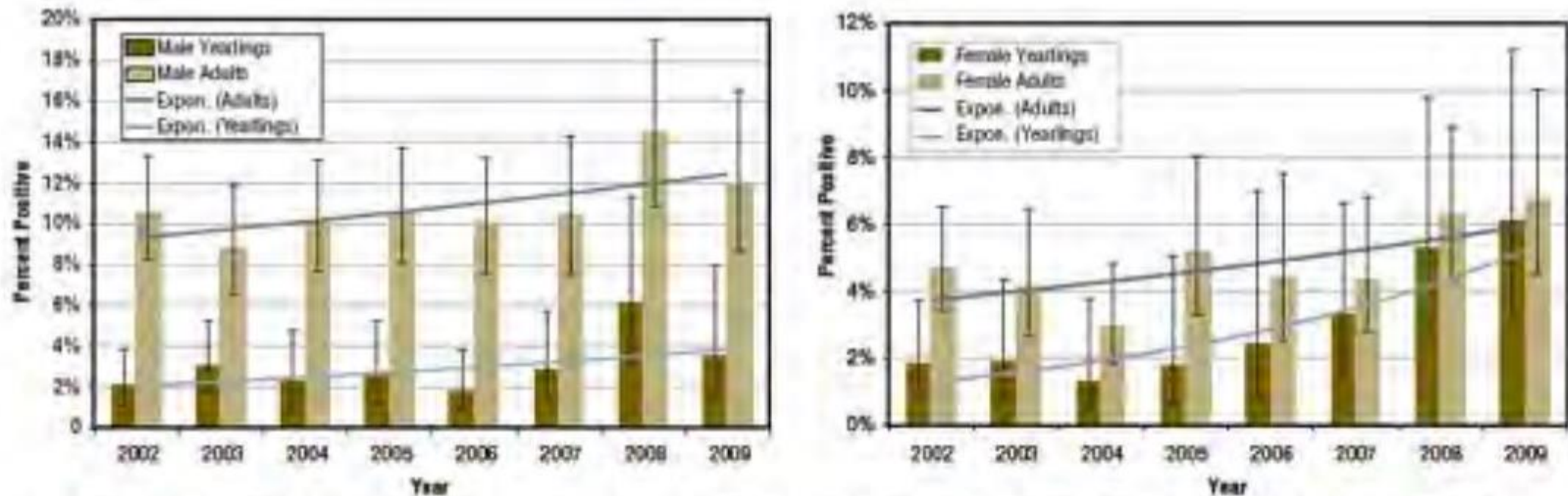
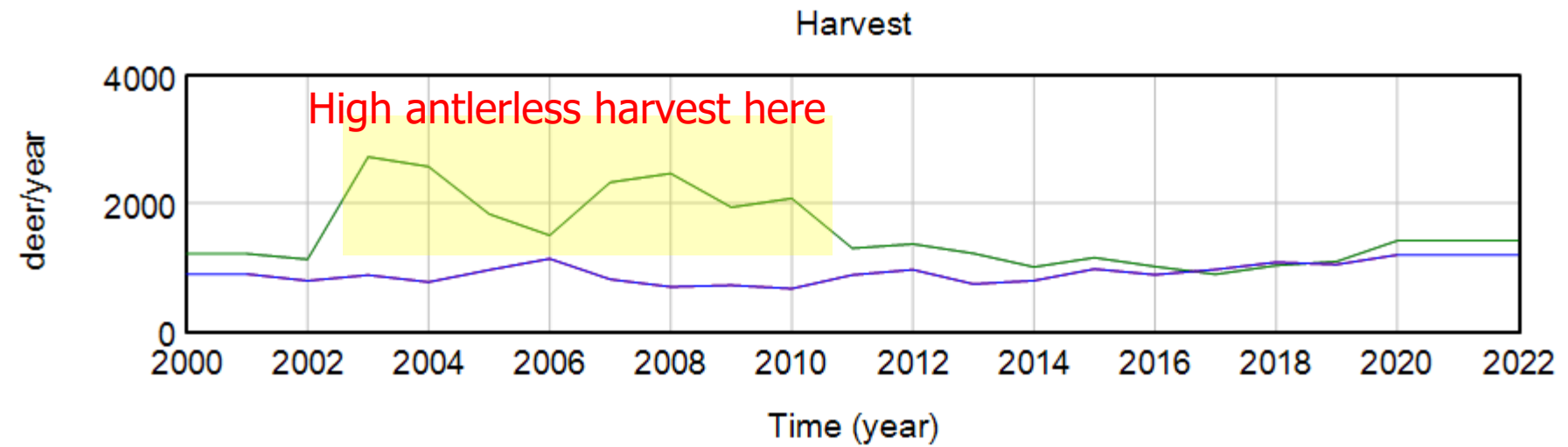


Figure 4. Estimated prevalence and exponential trend lines of CWD in yearling and adult male (left) and female (right) white-tailed deer from the western core monitoring area, 2002-2009. Vertical lines are 95% confidence intervals.

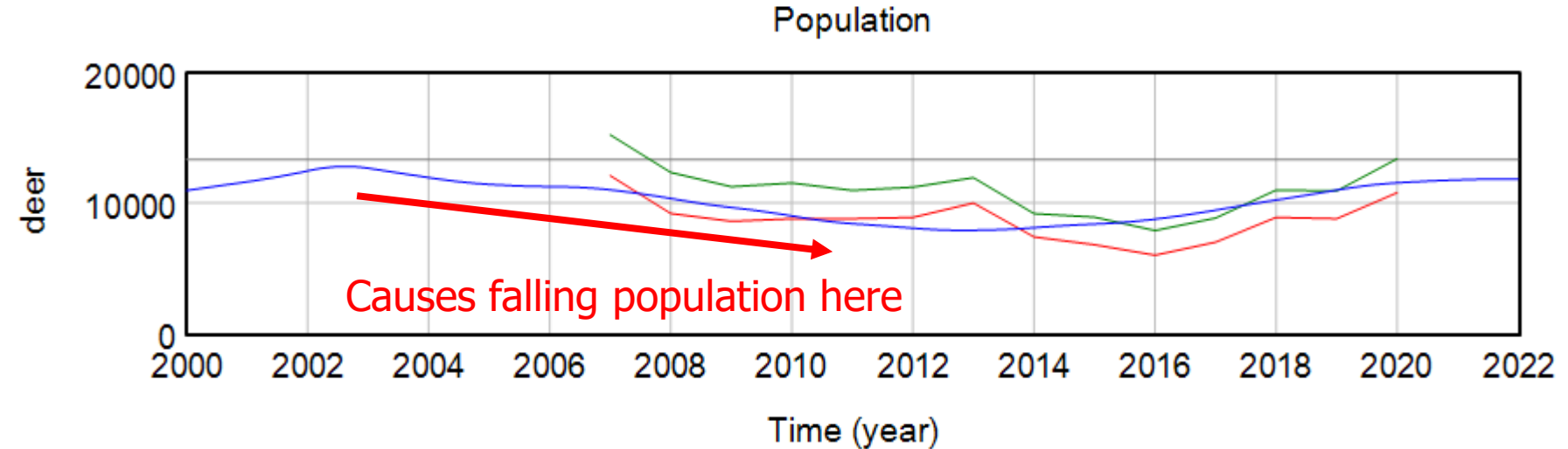
“ Figure 14 presents graphs used in the planning document. The graphs imply (using fitted exponential trend lines) an upward trend in infection rates, even for yearlings. Yet, the graphs also present 95% confidence limits for each year; and, in every case these limits overlap. From a statistical standpoint, this means there were no significant differences between years! **Wrong!**”

Also, illogical: if there's no evidence of exponential growth of a disease, that's a win for control!

A possible high DD history

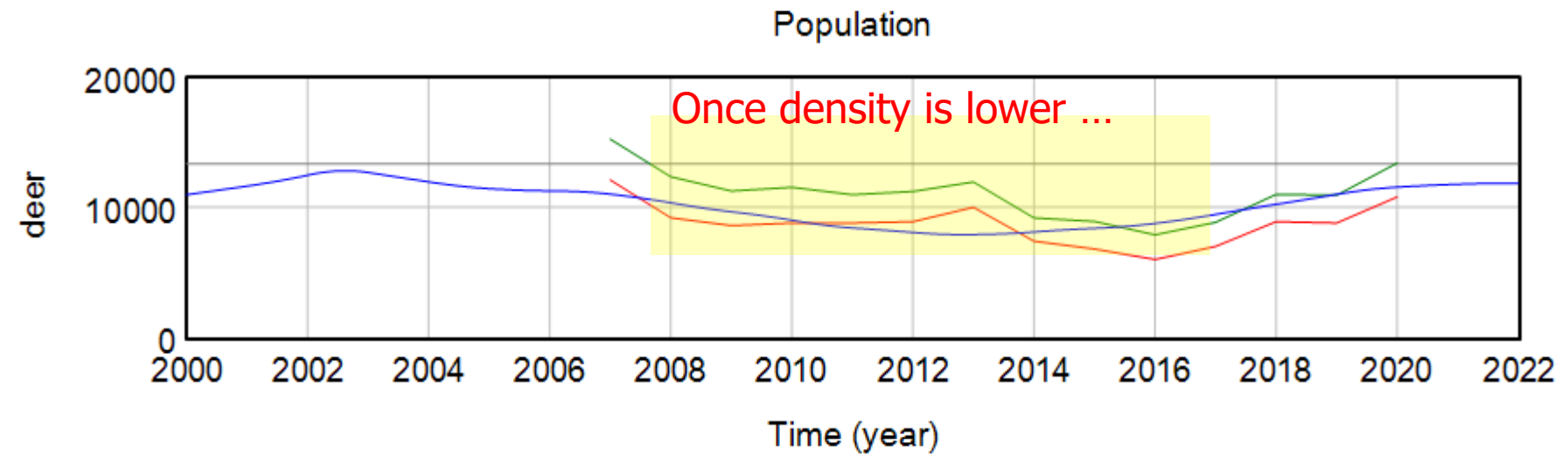


- buck harvest[Rock] : v30 priors high nod
- harvest bucks[Rock] : v30 priors high nod
- antlerless harvest[Rock] : v30 priors high nod

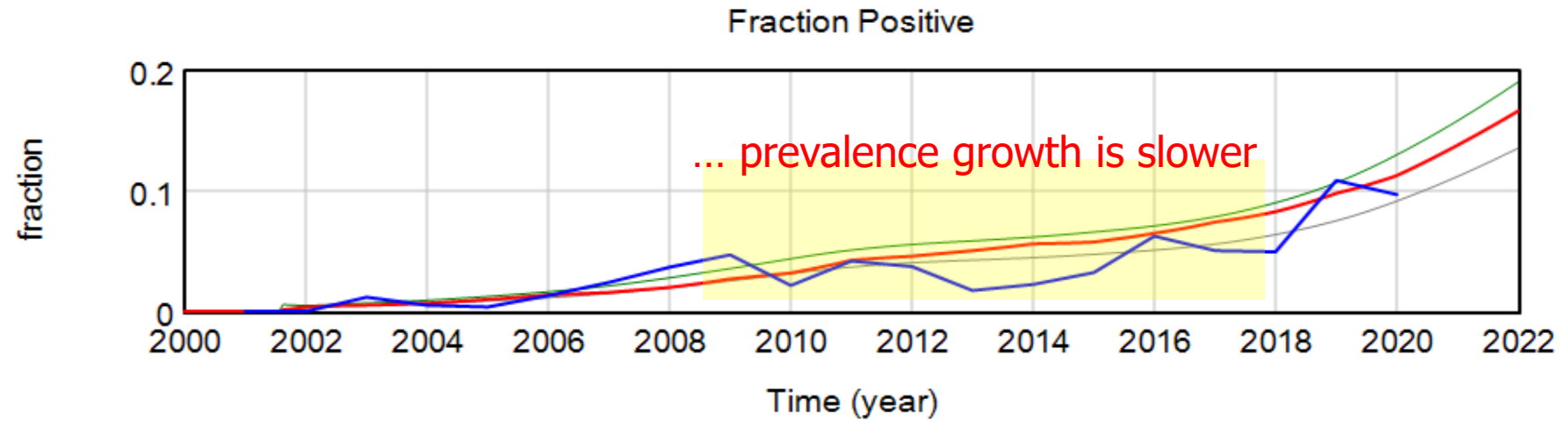


- population[Rock] : v30 priors high nod
- Post Hunt Deer Population Data[Rock] : v30 priors high nod
- Pre Hunt Deer Population Data[Rock] : v30 priors high nod

A possible high DD history

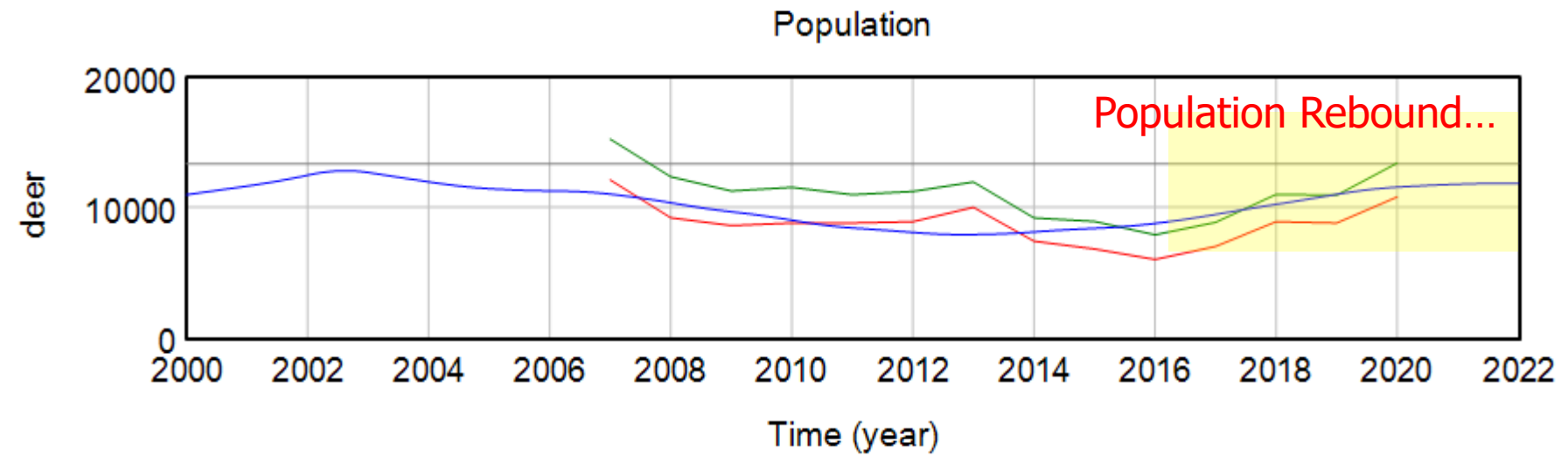


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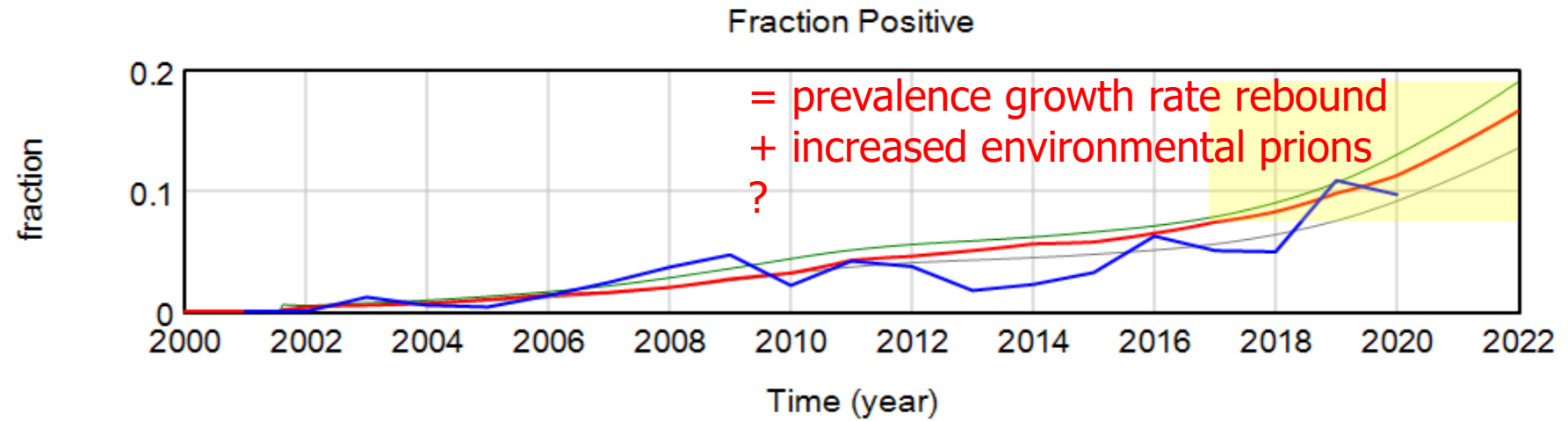


- fraction positive[Rock] : v30 priors high nod
- curr Fraction Positive[Rock] : v30 priors high nod
- true prevalence[Rock] : v30 priors high nod
- apparent prevalence[Rock] : v30 priors high nod

A possible high DD history

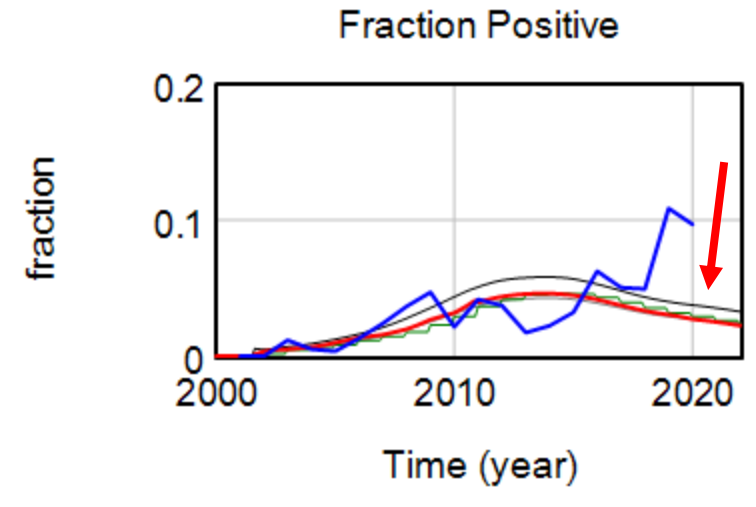
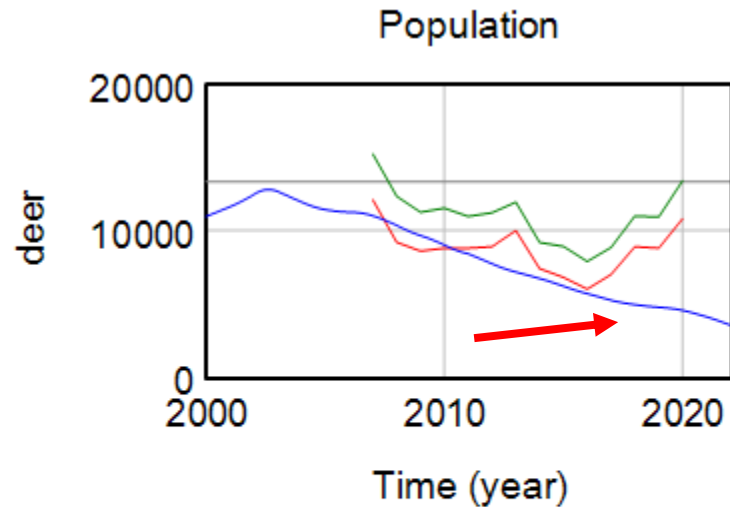
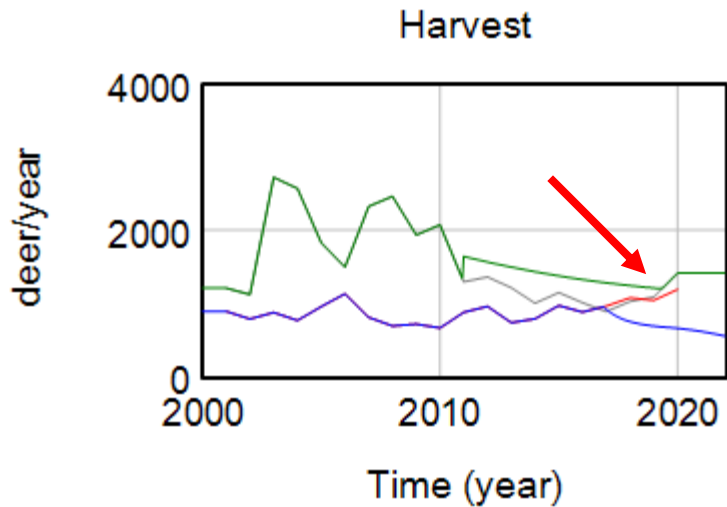


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- true prevalence[Rock] : v30 priors high nod
- apparent prevalence[Rock] : v30 priors high nod

What if the high antlerless harvests in 2003-2010 had been sustained?



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- harvest bucks[Rock] : v30 priors high co
- antlerless harvest[Rock] : v30 priors high
- harvest antlerless[Rock] : v30 priors high

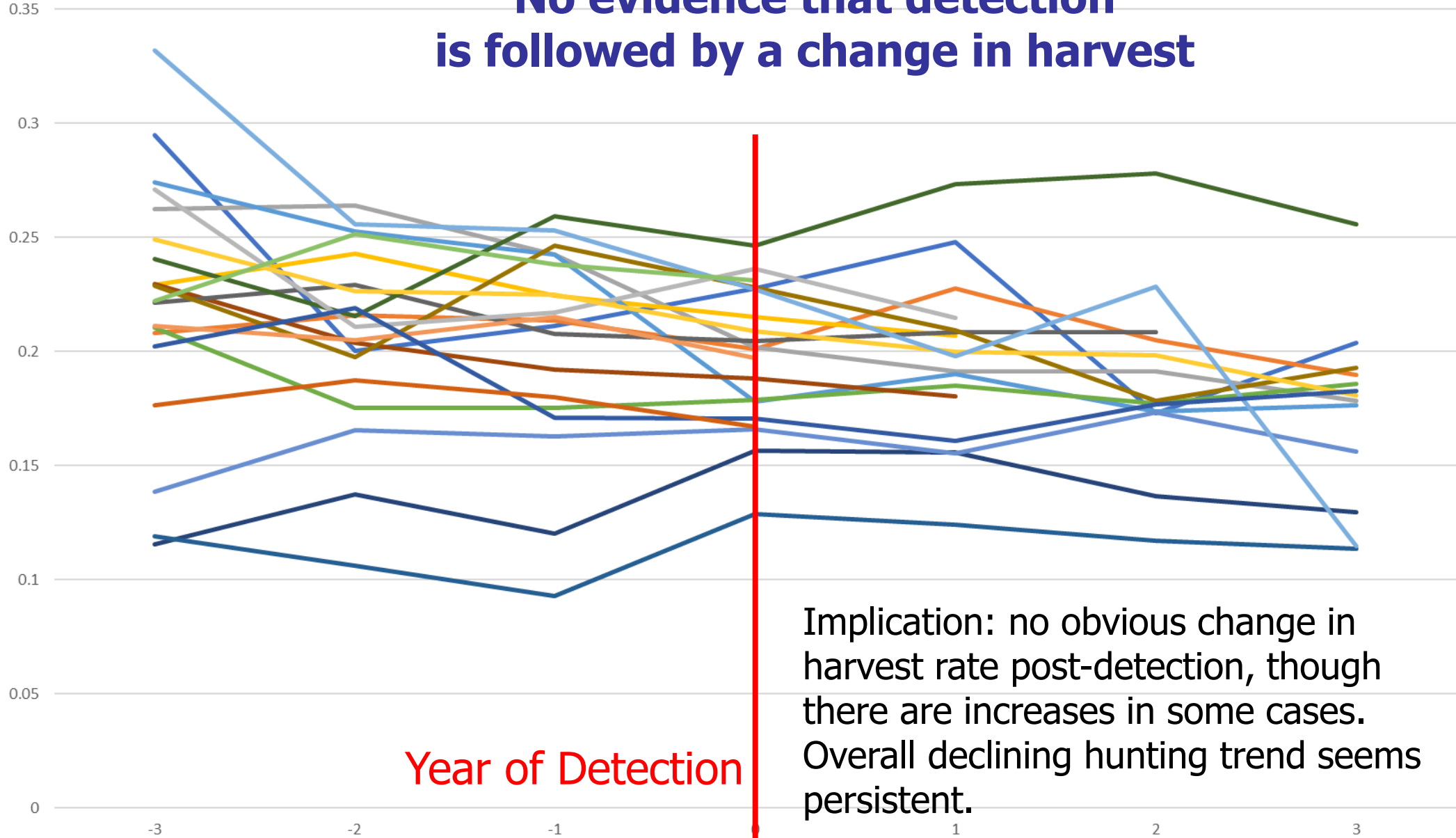
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- Pre Hunt Deer Population Data[Rock] : v
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- fraction positive[Rock] : v30 priors high c
- curr Fraction Positive[Rock] : v30 priors h
- Reported Fraction Positive[Rock] : v30 p
- apparent prevalence[Rock] : v30 priors h
- true prevalence[Rock] : v30 priors high c

First Detection Yr

Sum of fraction of population harvested

No evidence that detection is followed by a change in harvest



CountyID

- Adams
- Crawford
- Dodge
- Dunn
- Eau Claire
- Juneau
- Lincoln
- Marathon
- Marquette
- Milwaukee
- Oneida
- Portage
- Racine
- Shawano
- Sheboygan
- Vernon
- Washburn
- Washington
- Waukesha
- Wood

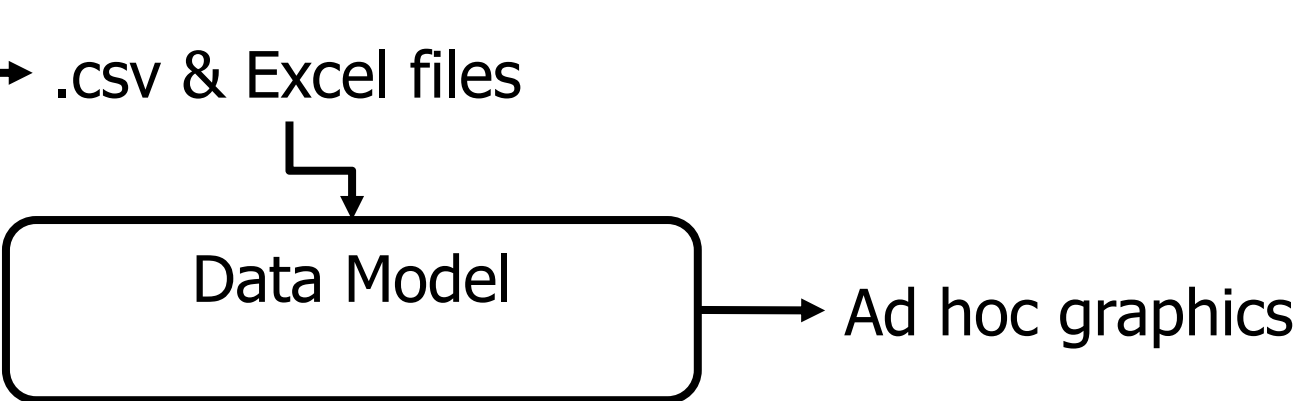
Year of Detection

Implication: no obvious change in harvest rate post-detection, though there are increases in some cases. Overall declining hunting trend seems persistent.

CWD Project Architecture

- WI DNR data
- Other sources (e.g., Census)

Data Team

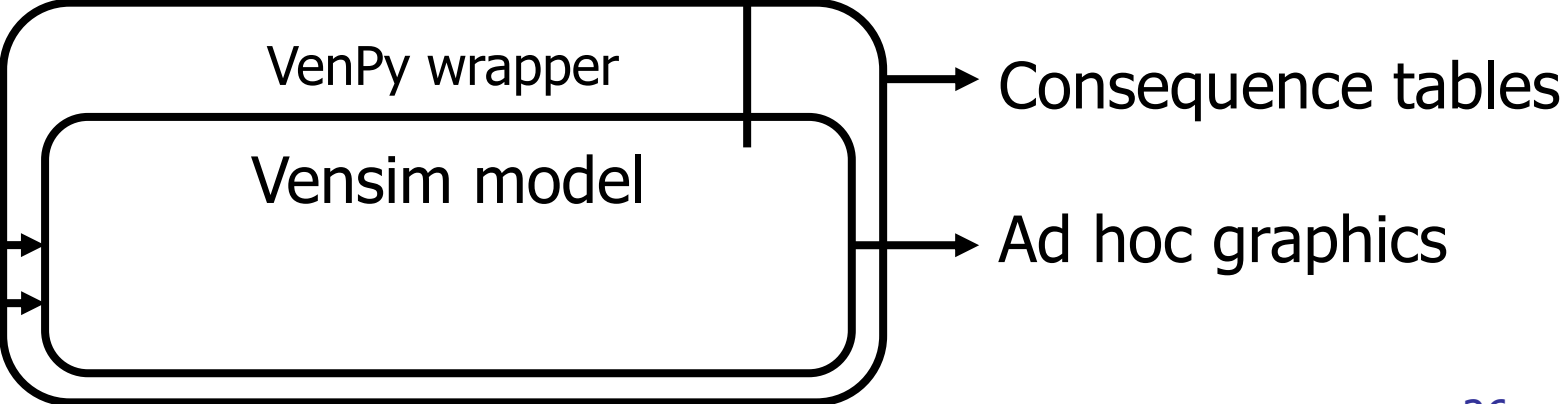


Initialization Data

"Stylized Facts", Reference Modes

Stakeholder Team

Model Team



Metrics
Action packages
(Excel)