Statistically Based Territory Modeling

Drew Lawyer – Sr. Professional Services Consultant

EARNIX
Predict. Perform.

Agenda

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- History of territorial modeling
  - Defining the business problem
- Modeling in practice
  - Residual analysis for creating rating territories and pricing
  - Directly modeling geo-effects
- Case Study – comparison of methods

History of Territory Modeling

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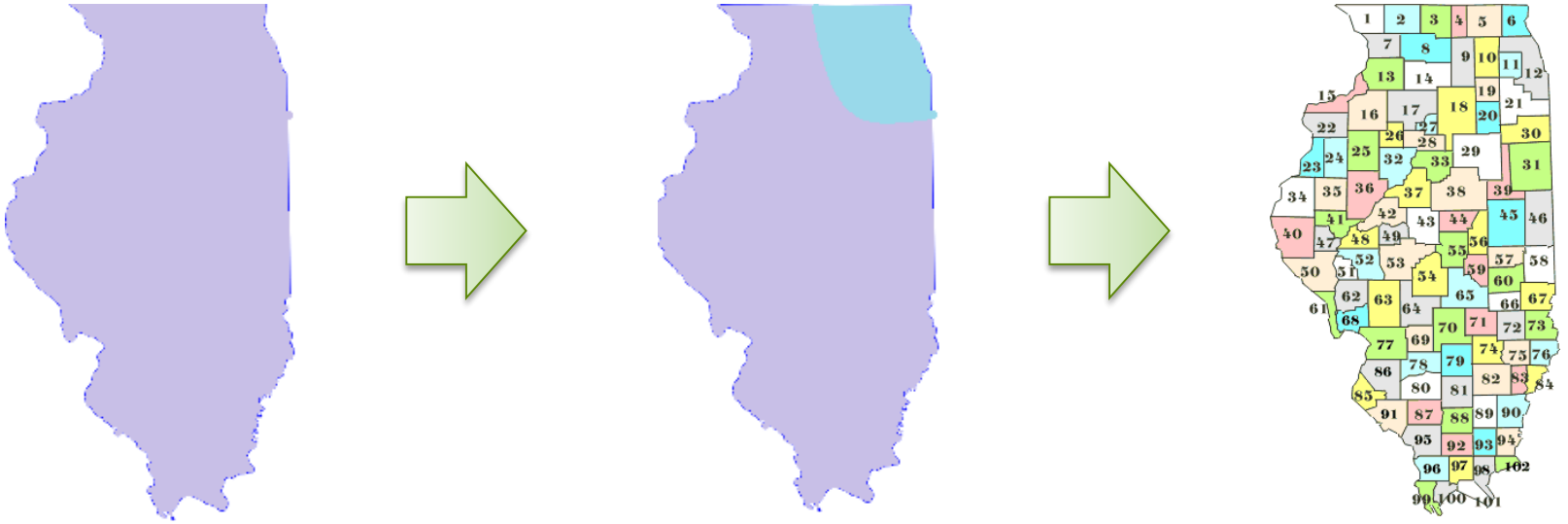
- As time has progressed territorial segmentation has gotten more granular



- This causes an issue when working in the current multi-variate GLM framework

Difficulties in Territory Modeling

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- Estimating loss cost for a granular location
- Creating territorial groupings for rating
- Variable have two levers (the price and the assignment)
- There is not a single agreed upon approach for defining and pricing territory
  - Low vs. High segmentation
  - Credibility weighting
  - Integrated competitor pricing
  - GLM vs. GAM

Advantages to Granular Segmentation

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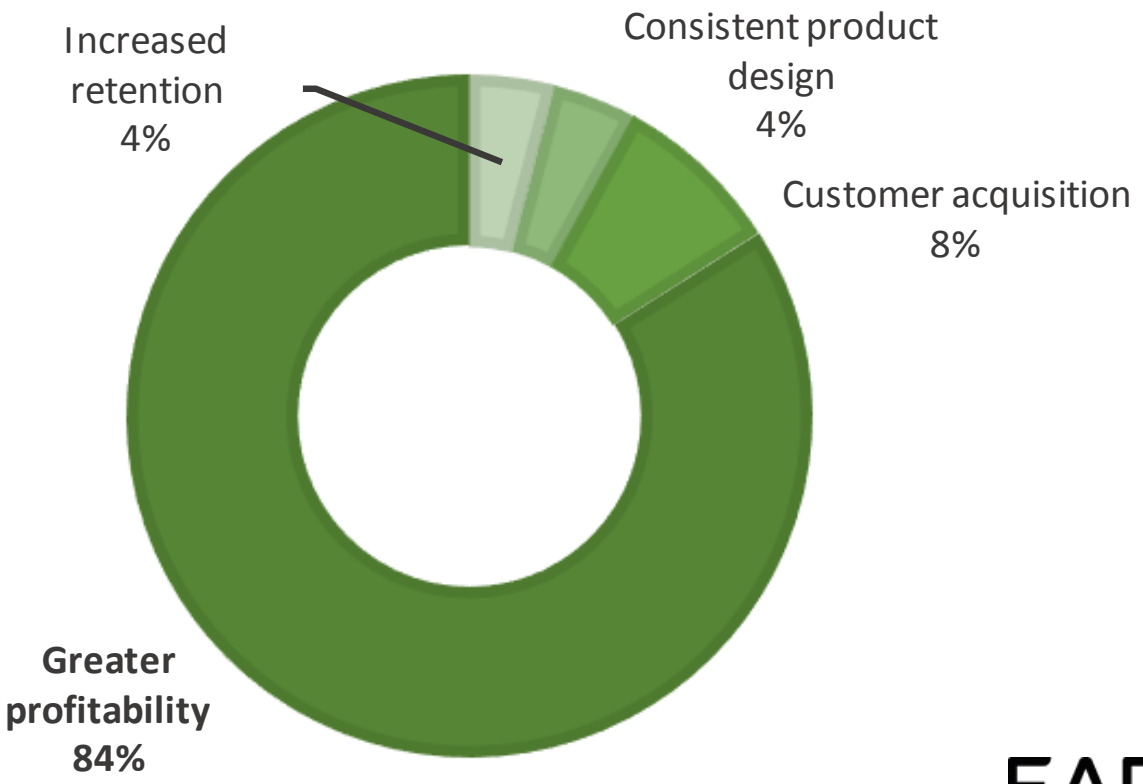
- Many of the largest insurers are filing rates by…
  - Zip code, Census tract, or Census block

- Avoid large rate differences between adjacent territories
- Avoid analytical issues with defining classic “territorial boundaries”
- More refined estimate of risk is a competitive advantage
  - Write and retain good risks
  - Send bad risks to the competition

Industry Survey

Rate Change Drivers: Strategic Goals

One way to achieve greater profitability is through **more refined segmentation**



Survey responses were collected online from 99 insurance professionals representing companies that sell Homeowners coverage in the United States and Canada

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- **Modeling in practice**
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Approaches to Territory Modeling

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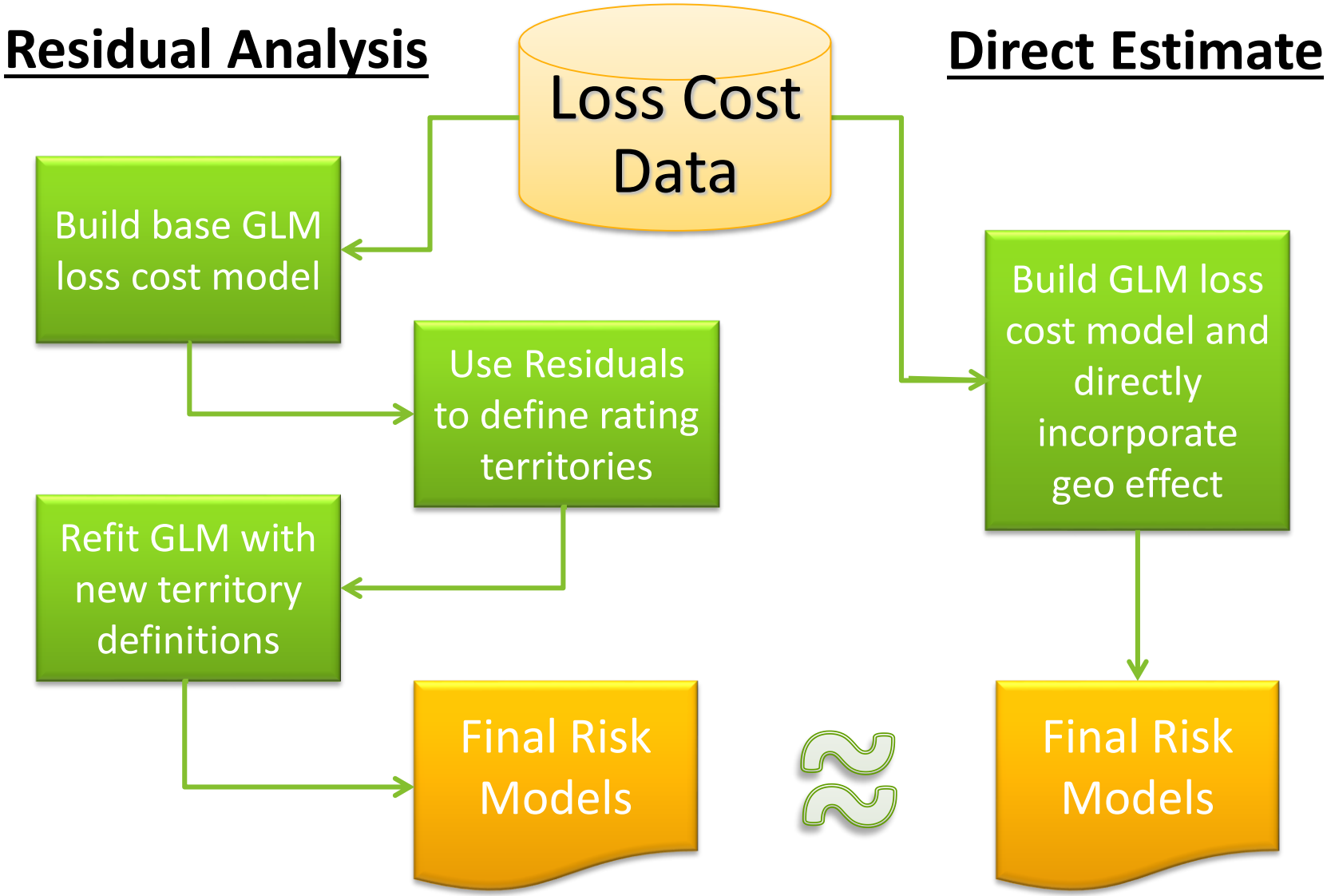

Approaches to Territory Modeling

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- **Residual Analysis**
  - High level of control over estimates
  - Clean fit into a multiplicative rating structure
  - Time consuming multi-step process
- **Direct Estimate**
  - Simplified modeling process
  - Intuitive interpretation of results
  - Lack of control over estimates
  - Additional work is required to create a multiplicative structure

Data for Analysis

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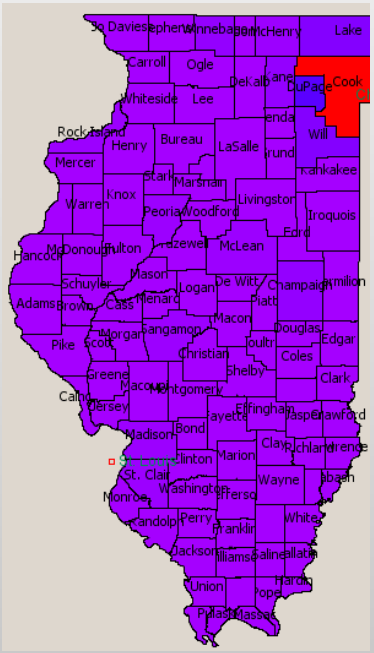
- Homeowners loss data in Illinois provided by large insurer
- Exposure years 2007-2011 & 2013
- 826,000 exposure years
  - 2007-2011 used for model development
  - 2013 used for comparison of results
- Risk models developed non-weather peril
  - Fire, Theft, Water, and Other
- Tweedie GLM used to model pure premium

Pop Density



Methodology is applicable for other business lines

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Approaches to Territory Modeling

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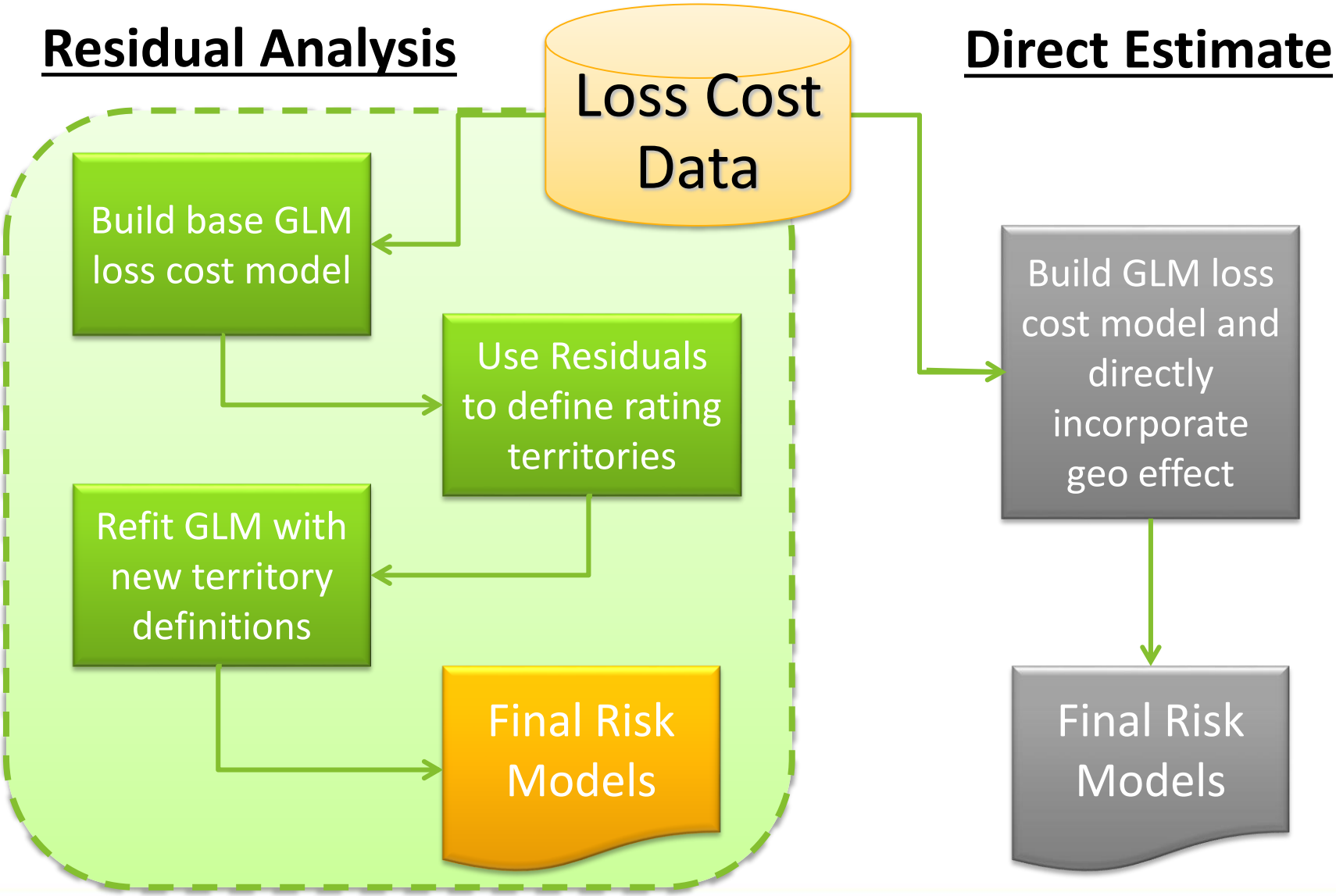

Residual Territory Modeling

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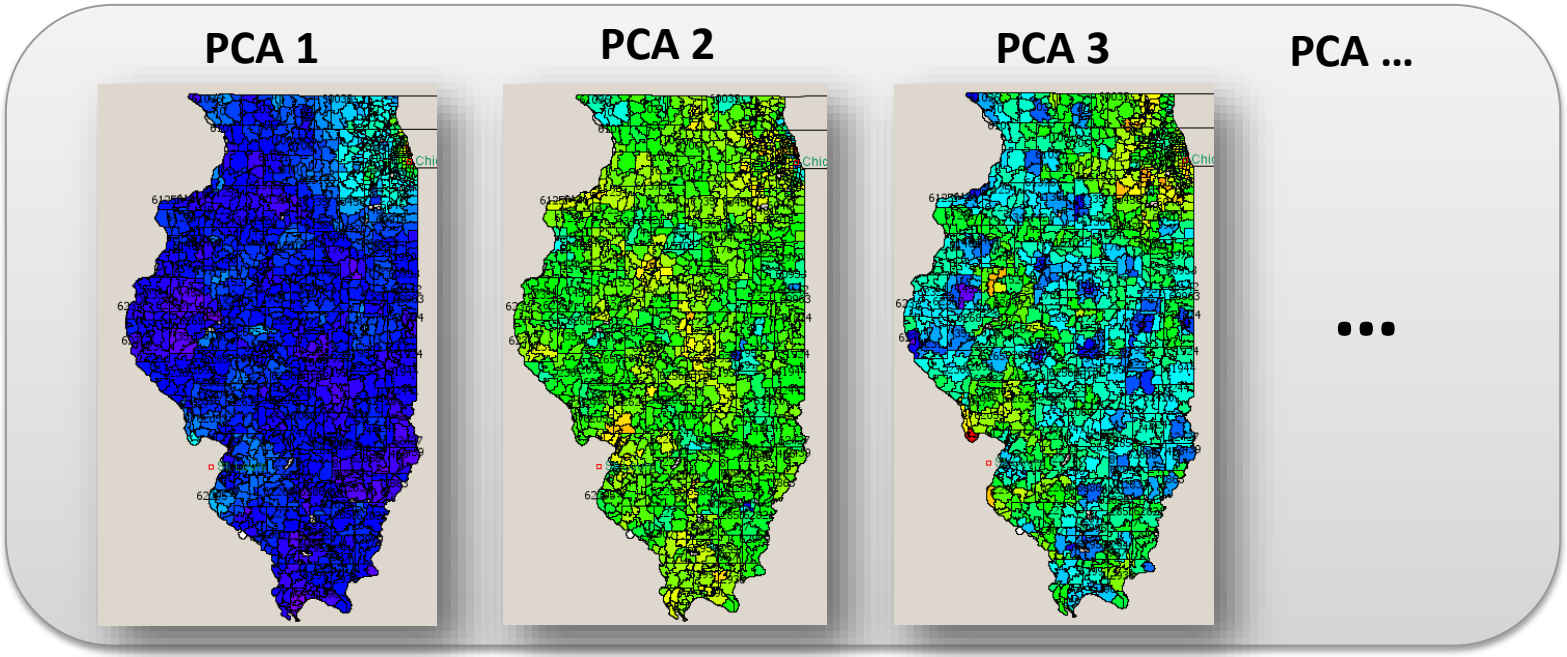
- Develop initial countrywide loss cost models by peril
- Models include principal components (PCA) of geo-demographic data not used in rating



- Starting point for all state specific models

Residual Territory Modeling

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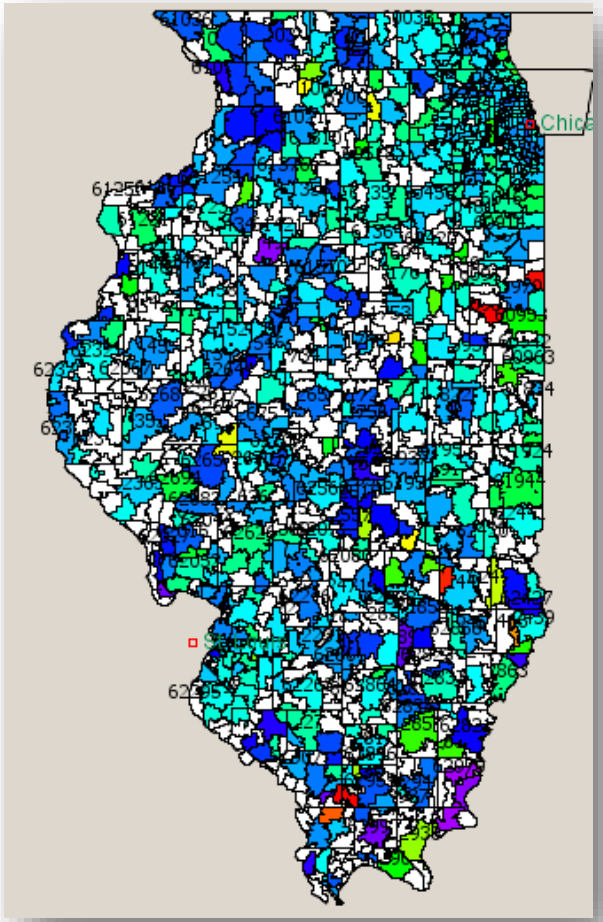
- The residuals for a specific state are tabulated by census tract
- Unsmoothed, the residual output appears as noise.
- It is possible that not all tracts have exposures
- A smoothing function is applied to the residual



Residual Territory Modeling

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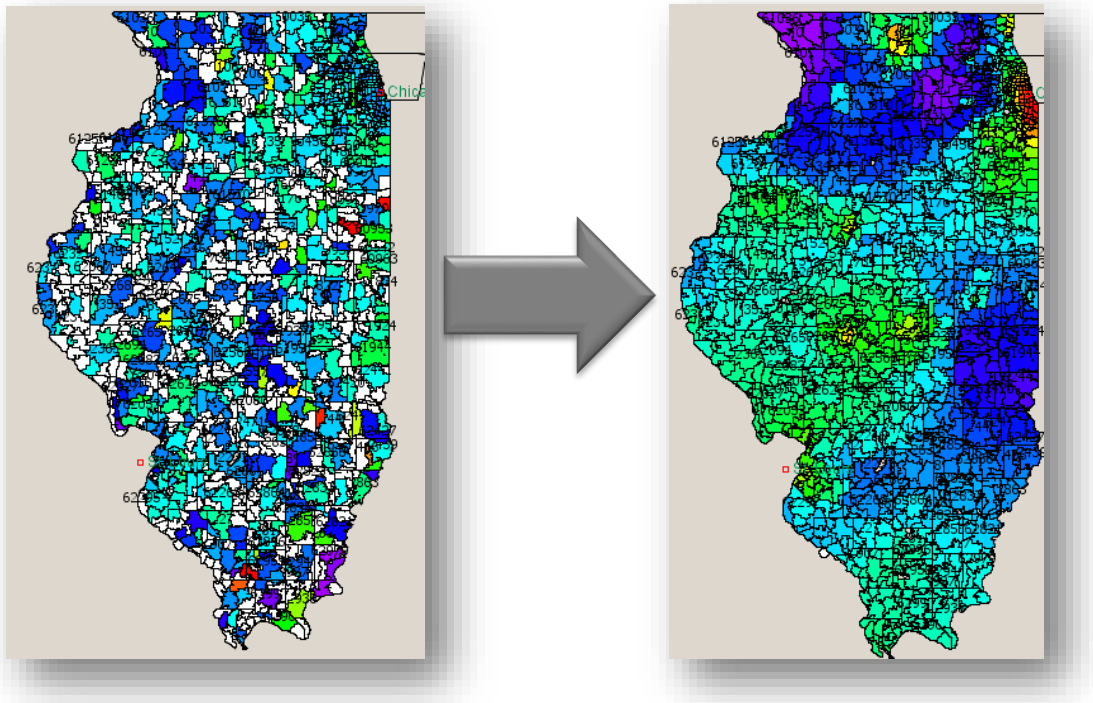
- The smoothing algorithm removes noise and draws out the signal
- The resulting estimates by census tract are then placed into 100 noncontiguous groups*



* modeler/company preference dictates smoothing method, number of groups, and other inputs into the smoothing

Residual Territory Modeling

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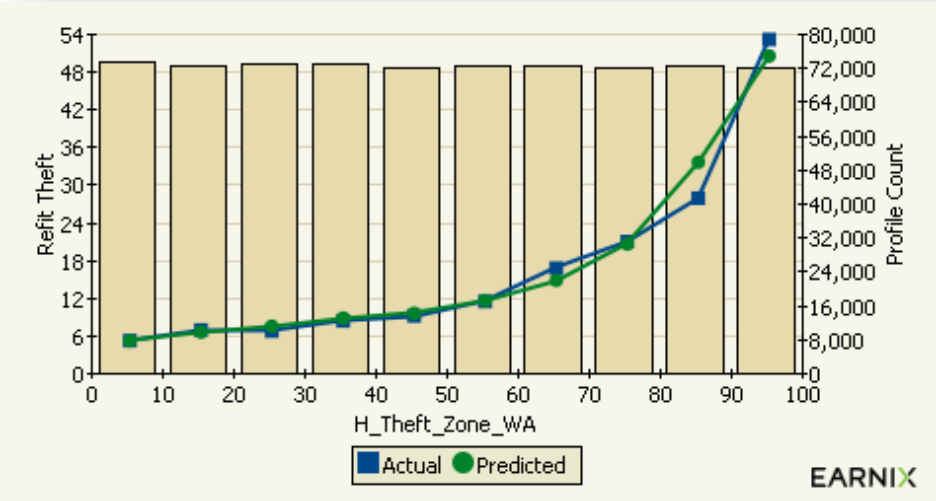
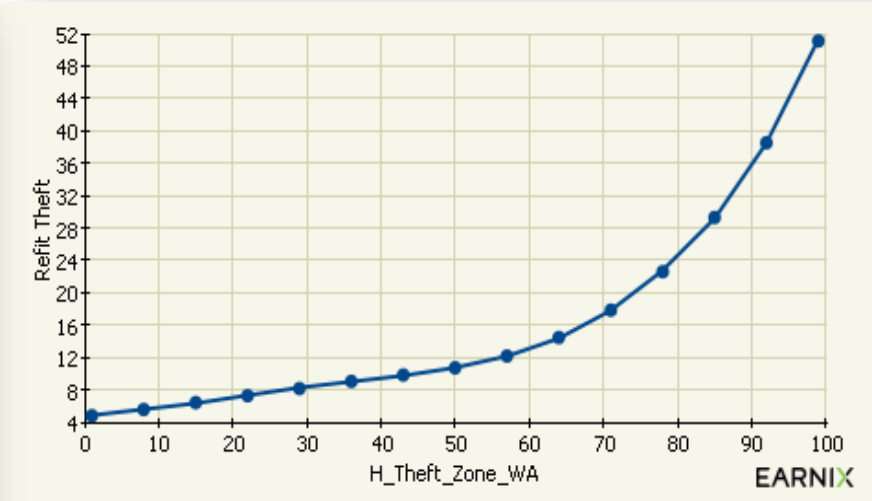
- The ordered groups are now returned to the risk model
- The other betas are fixed (offset) and the PCA's are removed
- The territorial effect is then fit with some type of variate





- The final result is 100 price points by census tract

Residual Territory Modeling

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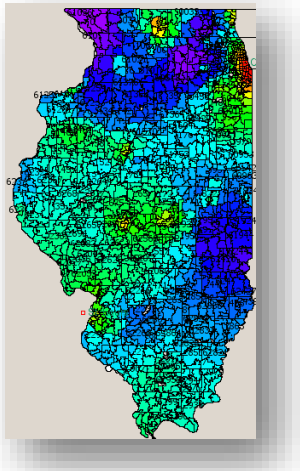
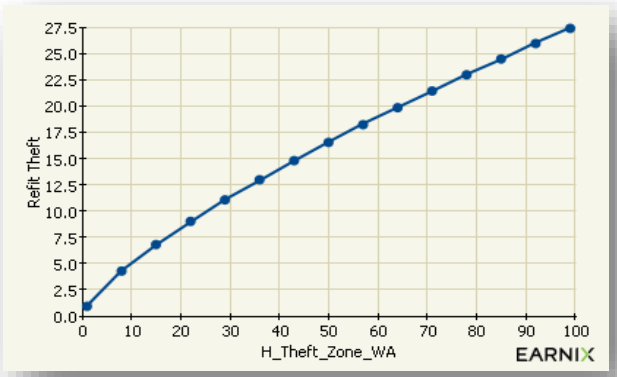
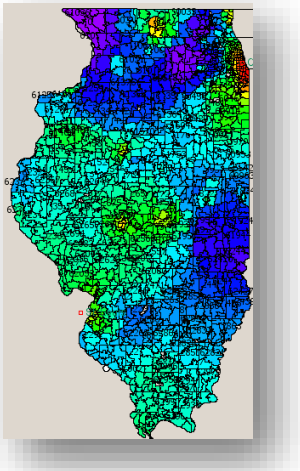
Theft Territory

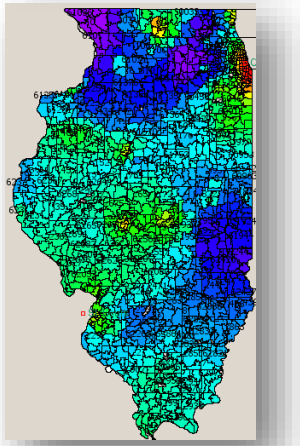
Theft Territory Model Fit

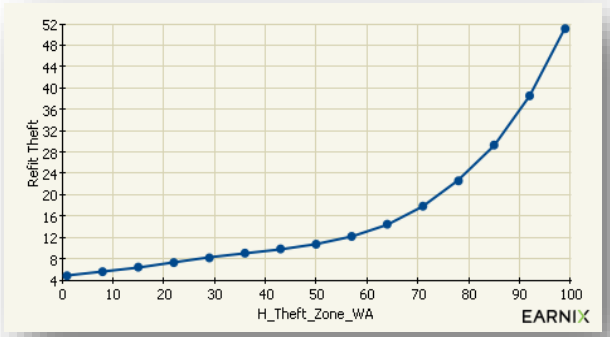
Theft Factor

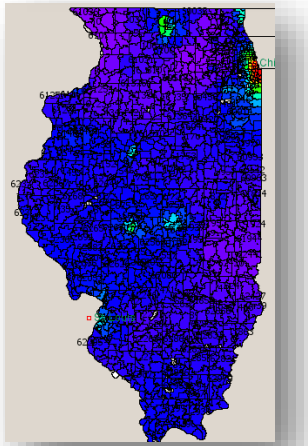












Residual Territory Modeling

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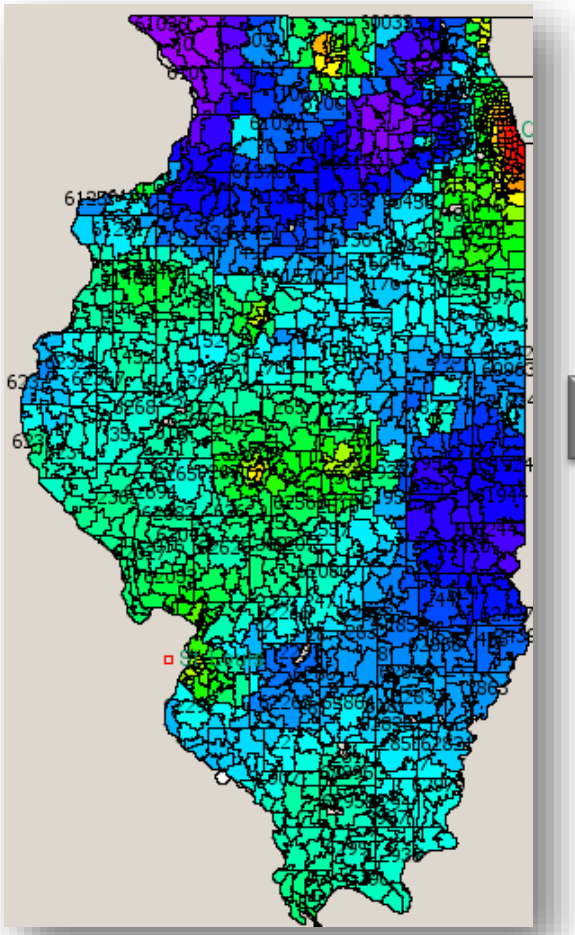
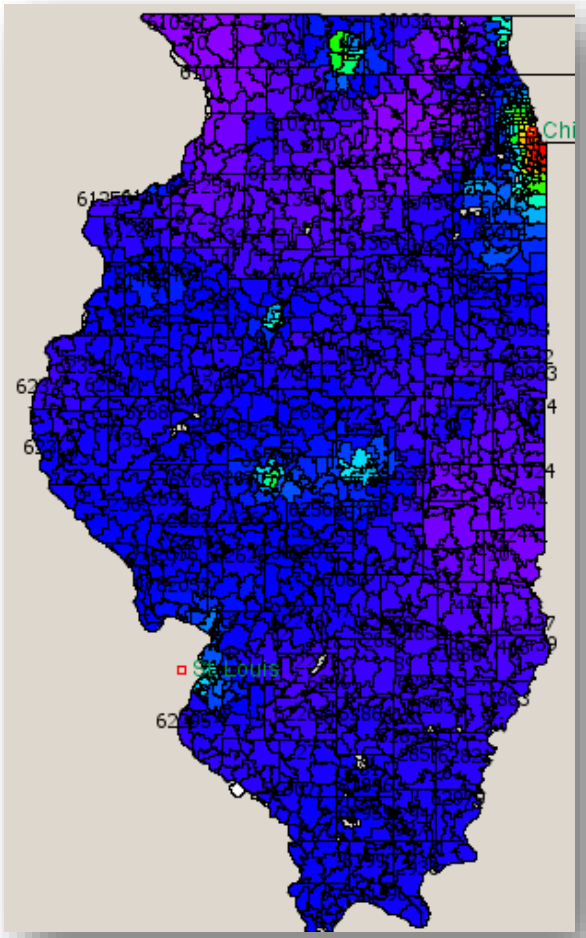
Theft Territory



Theft Factor



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Approaches to Territory Modeling

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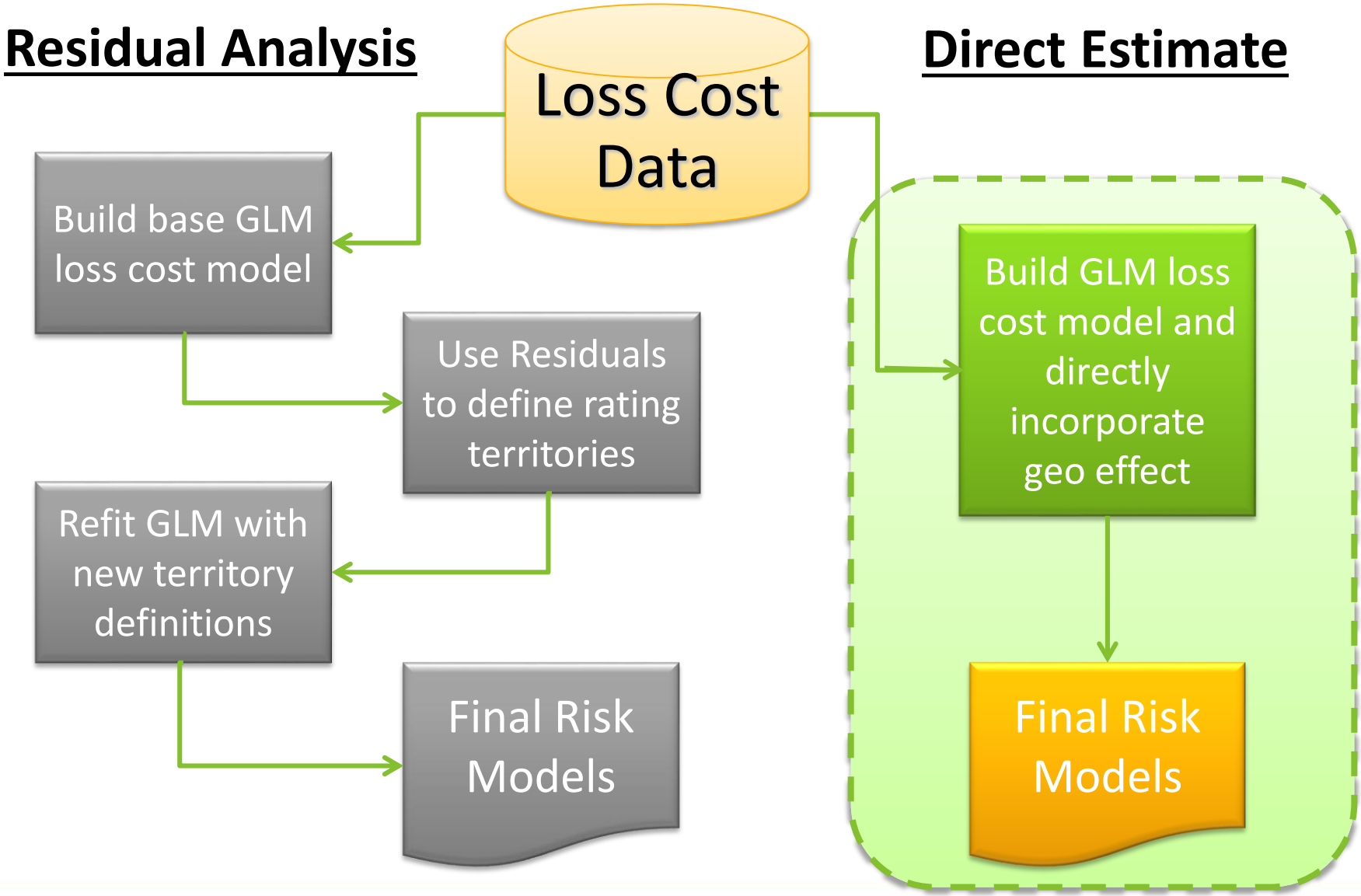

Direct Estimate of Geo Effect

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- After developing the initial countrywide loss cost models
- Again, remove the PCA's and fix (offset) other rating factors
- Add the geo parameter to account for the territorial effect
  - Geo parameter is built using latitude and longitude
  - Can either be defined using customer geo-coding (specific location for each customer) or mapping lat/long to the geo root level (e.g. census tract)

Direct Estimate of Geo Effect

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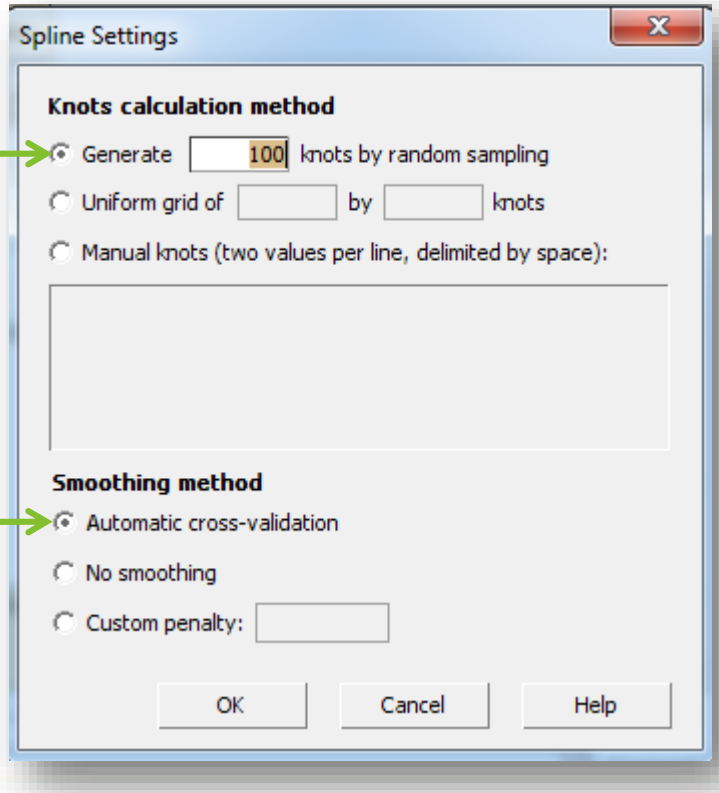
- The smoothing algorithm is applied to the geo parameter to draw out the signal
- Can be done in different software; methods vary slightly
- Earnix uses thin-plate splines for smoothing

Generate knots by random sampling will add knots randomly proportional to observation density

Cross-validation ensures that the geo effect does not overfit the data



Direct Estimate of Geo Effect

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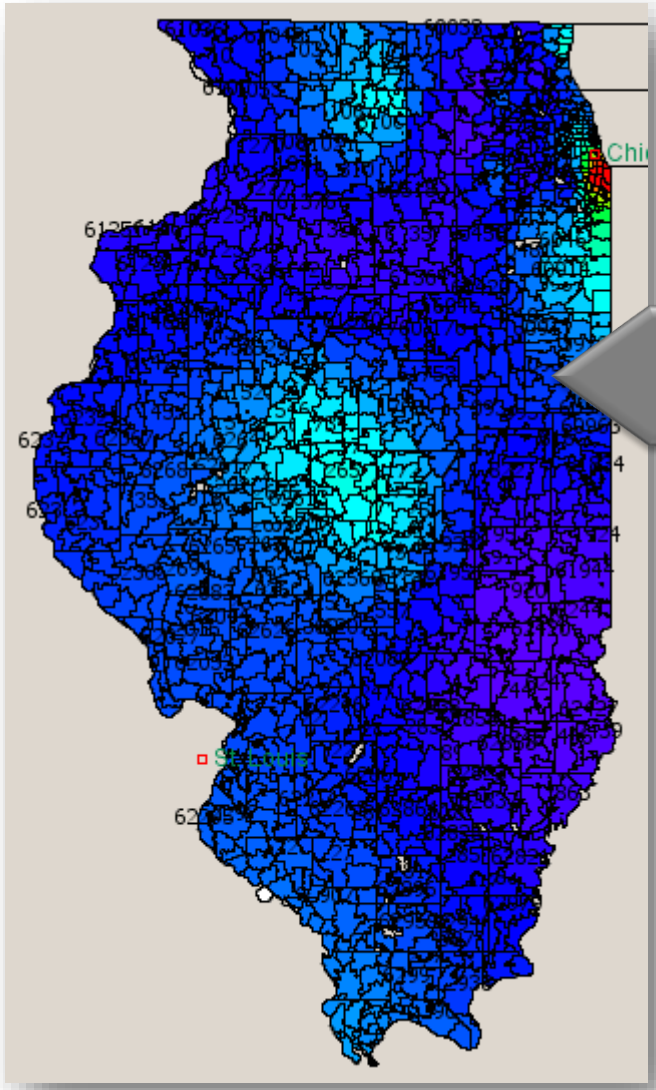
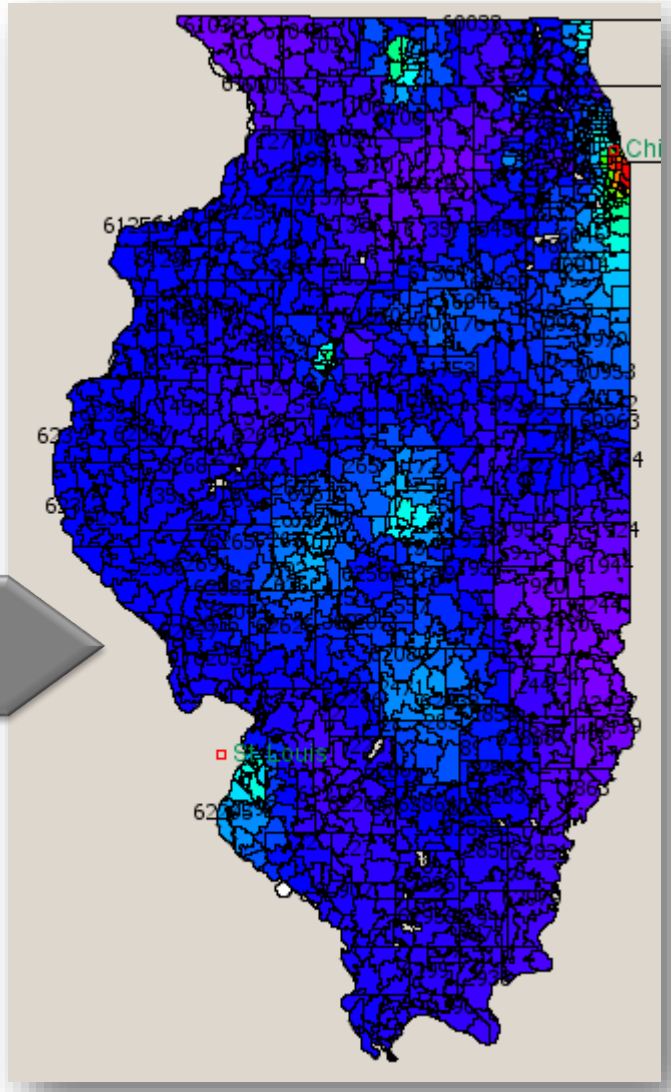


50 Knots

100 Knots



Direct Estimate of Geo Effect

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- Determining the proper number of knots is an iterative process.
- Cross-validation reduces the chances of overfitting the geo effect; however, it is still possible.
- Each census tract is defined as its own territory. If desired, neighboring tracts can be grouped together.
  - Useful if extreme values are identified
- Due to the nature of thin-plate splines the GLM loss cost model is actually transformed into a GAM
- The functional form can easily be converted back to multiplicative where a rating factor is assigned to each census tract

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Comparison of Results – Theft Peril

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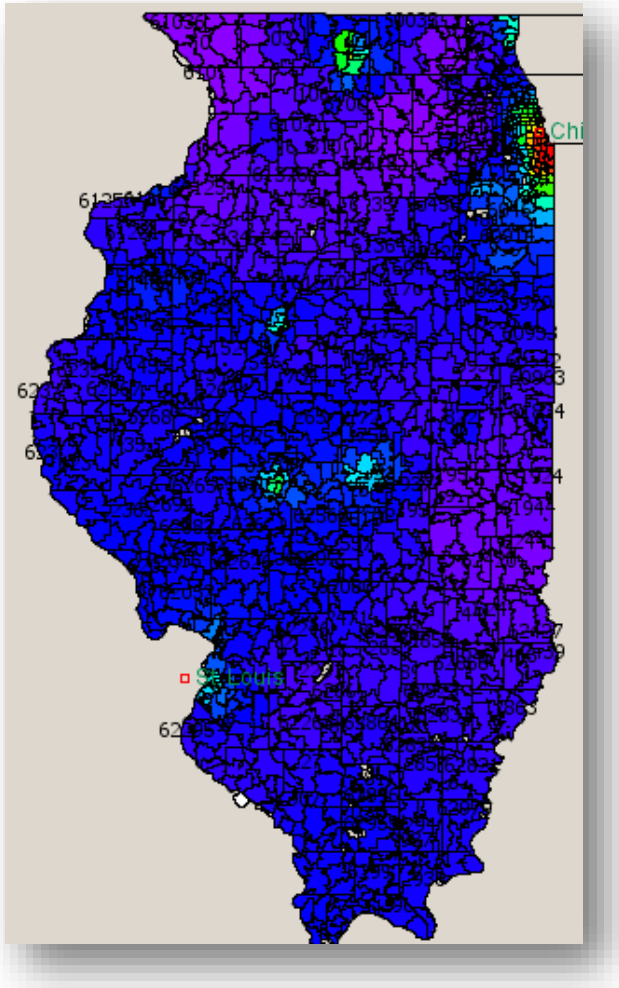
Residual Territory Modeling



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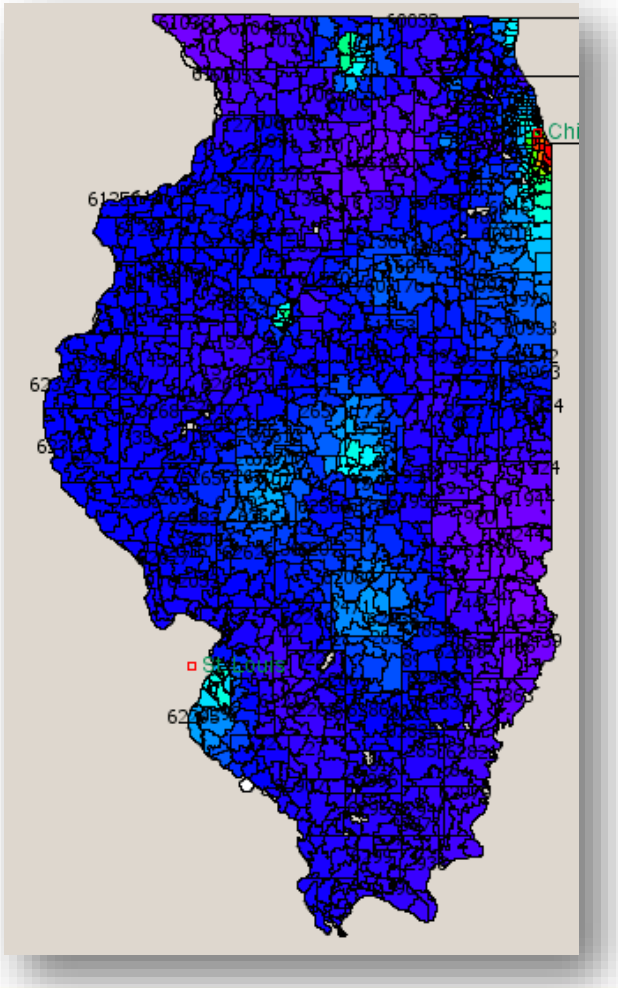
Direct Estimate



Comparison of Results – Theft Peril

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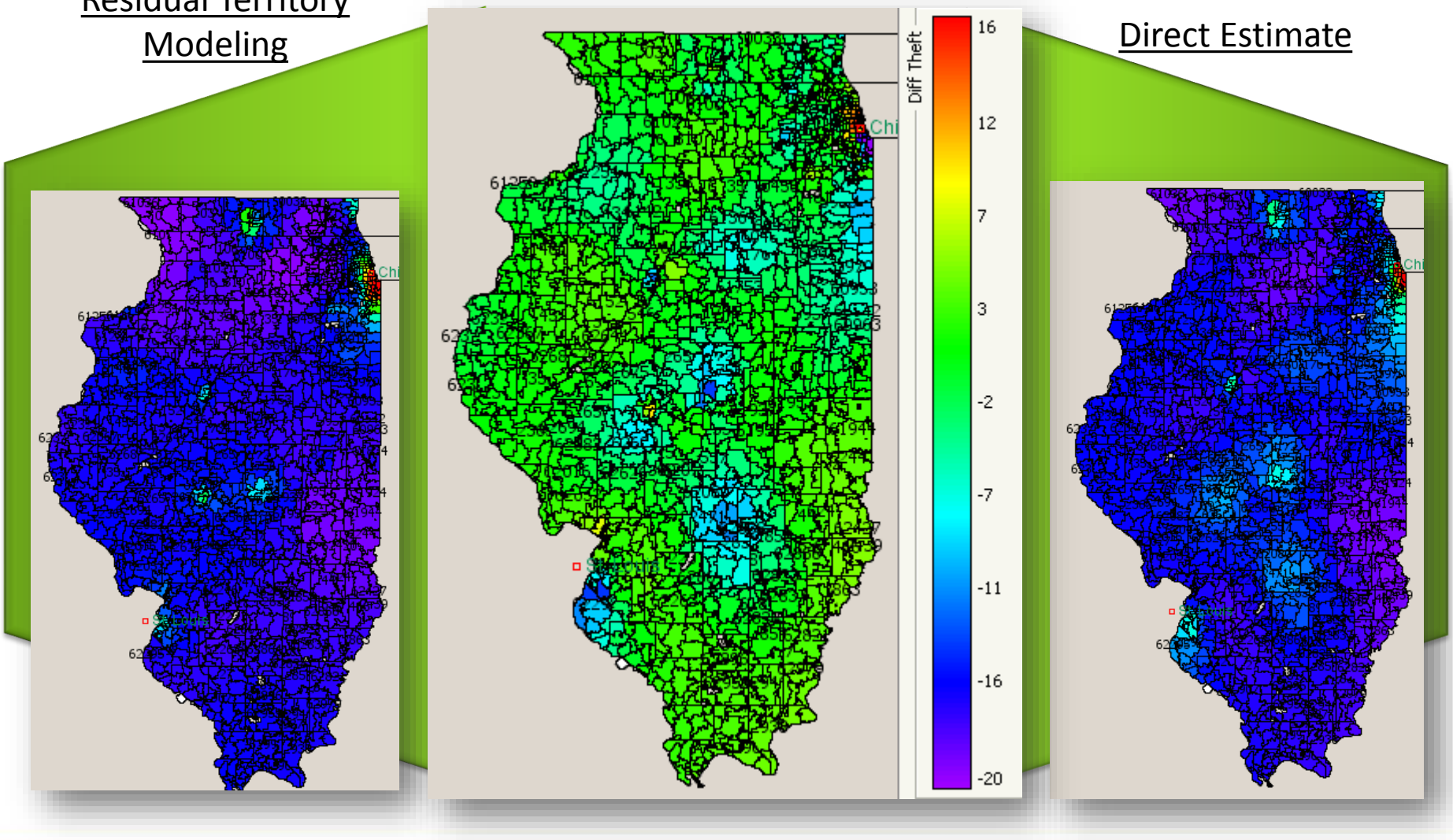
Residual Territory Modeling

Difference in Theft Premium

Direct Estimate



Comparison of Results – Theft Peril

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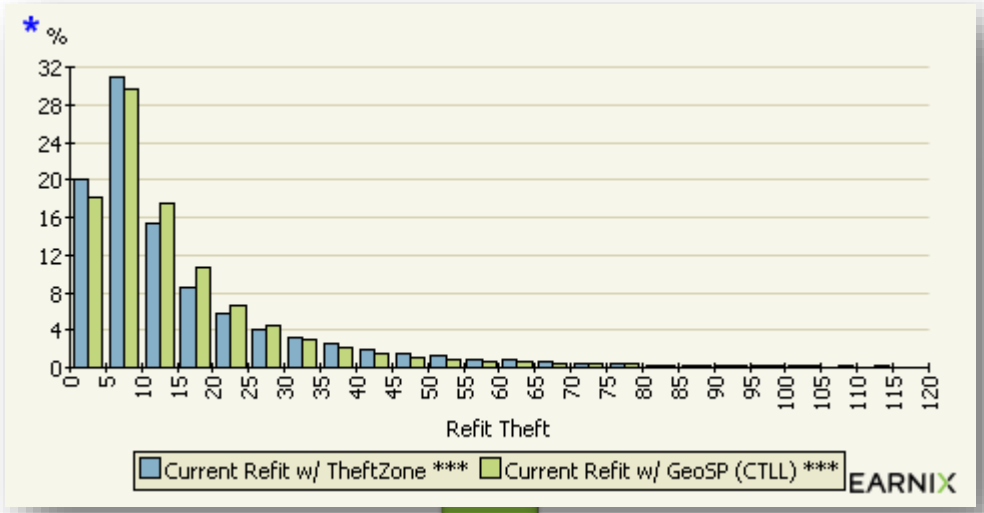
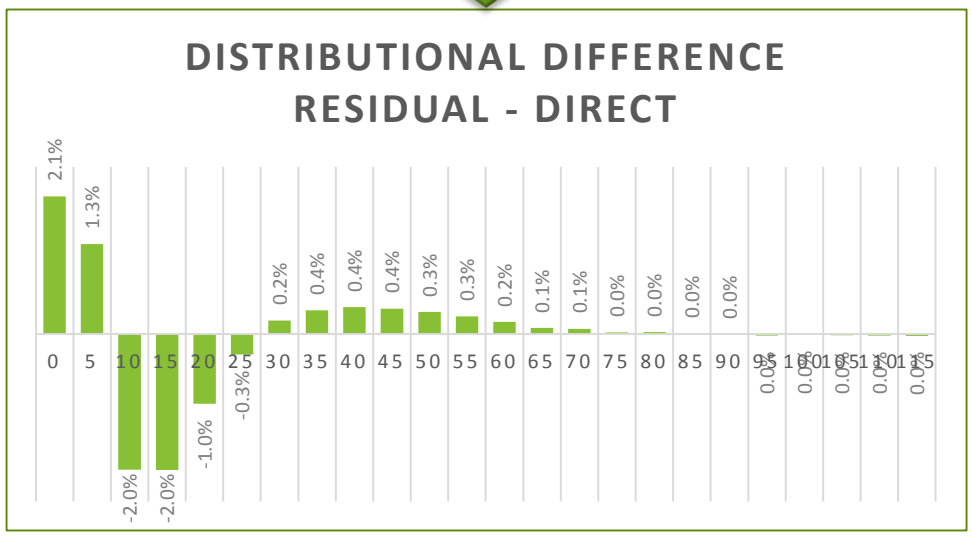
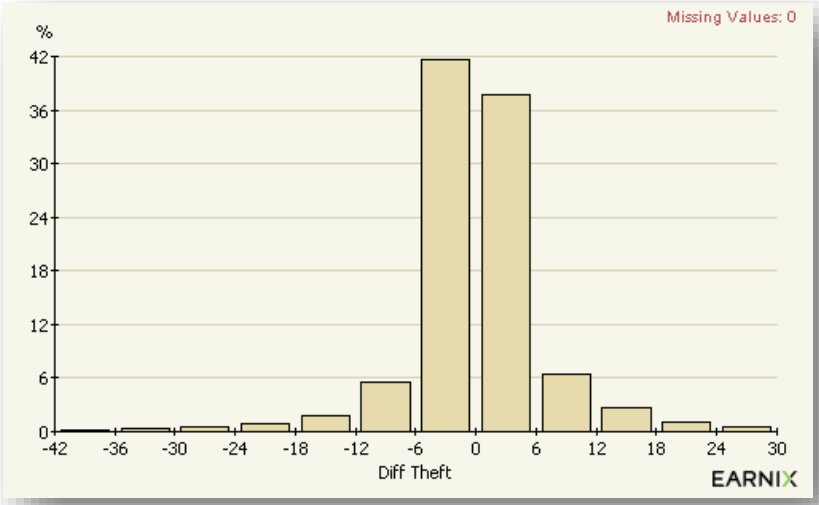


Range Analysis	Residual Modeling	Direct Estimation
1st Percentile	$2	$2
99th Percentile	$96	$107
Range (inner 98%)	$94	$105



50% exposures within +-$2



Comparison of Results – Water Peril

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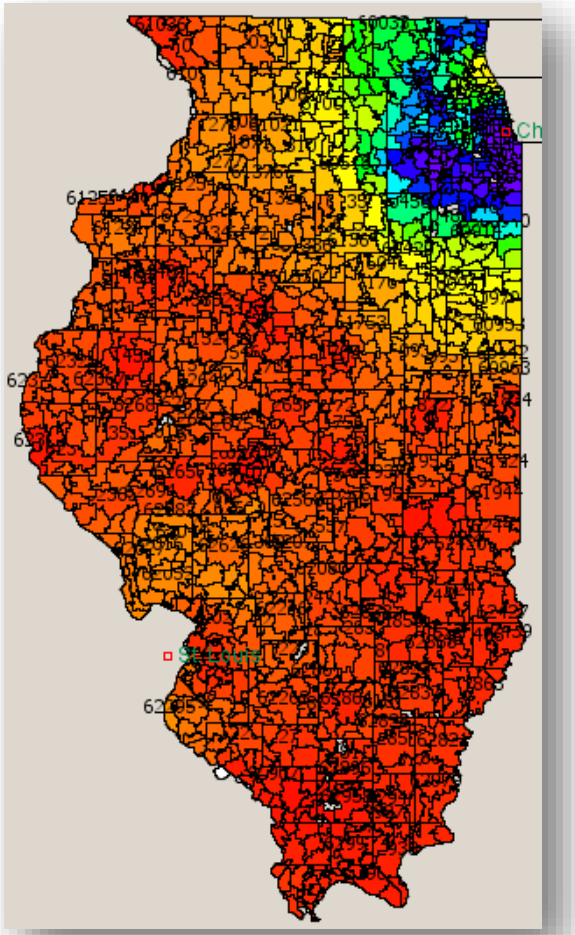
Residual Territory Modeling



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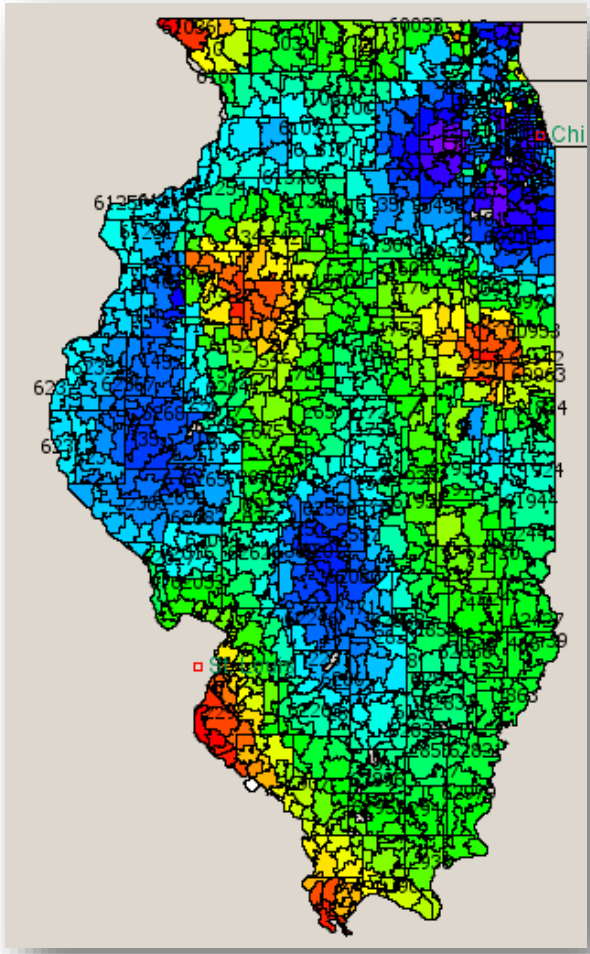
Direct Estimate



Comparison of Results – Water Peril

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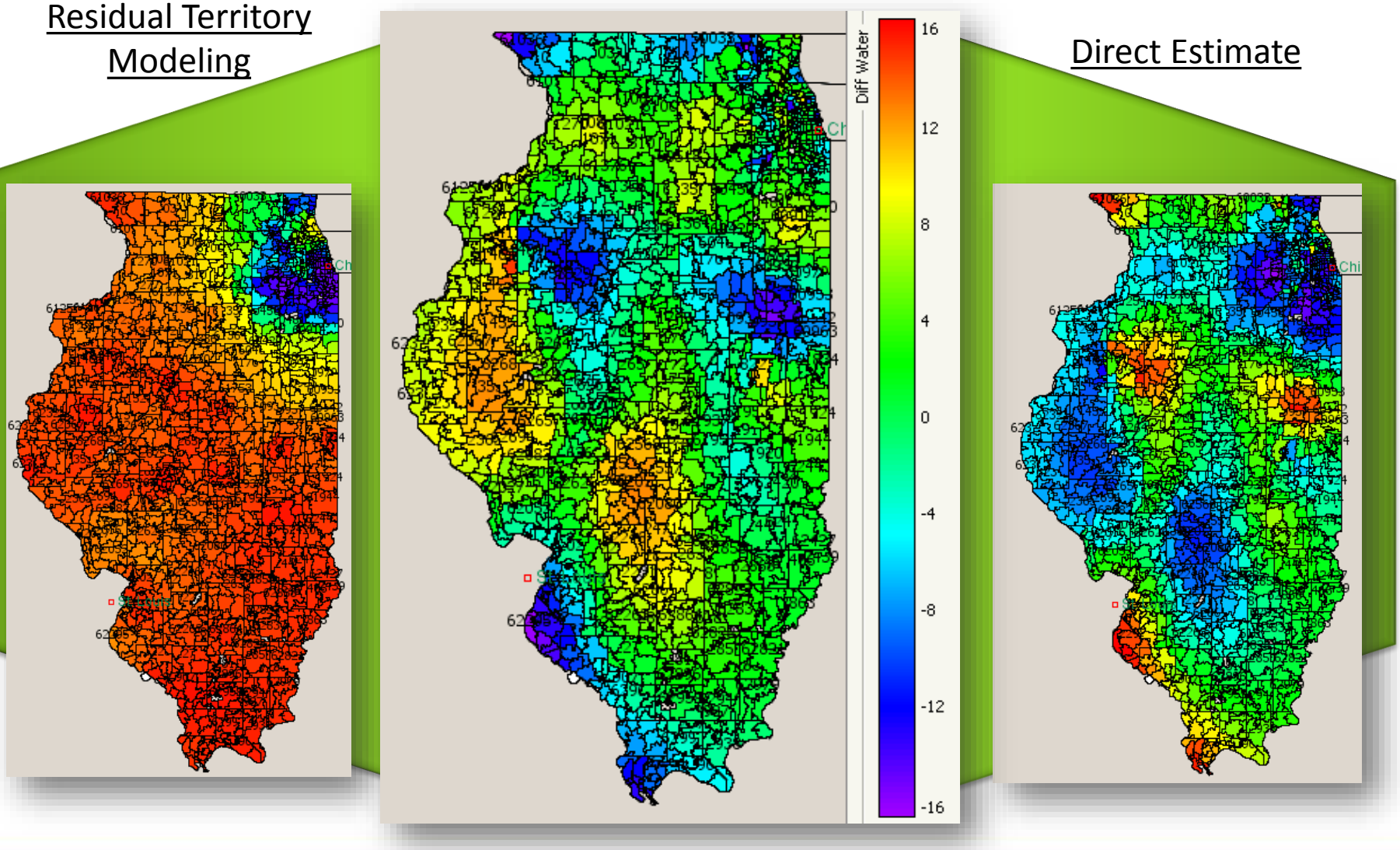
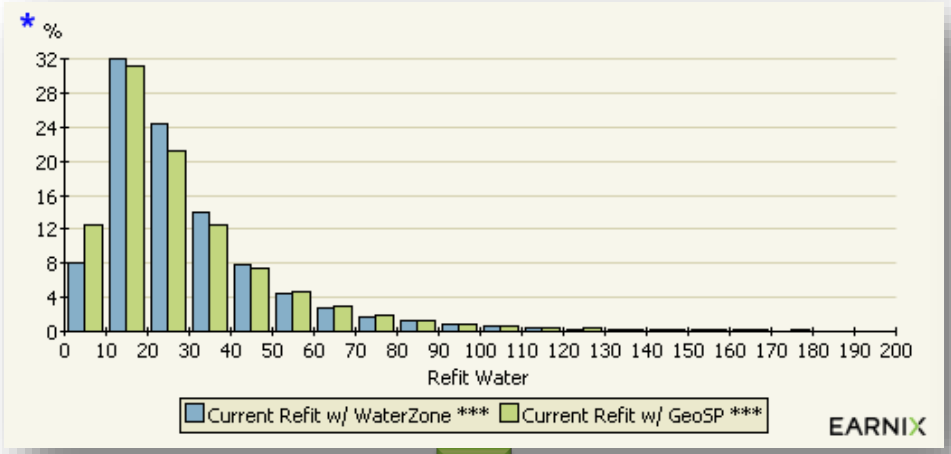
Residual Territory Modeling

Difference in Water Premium

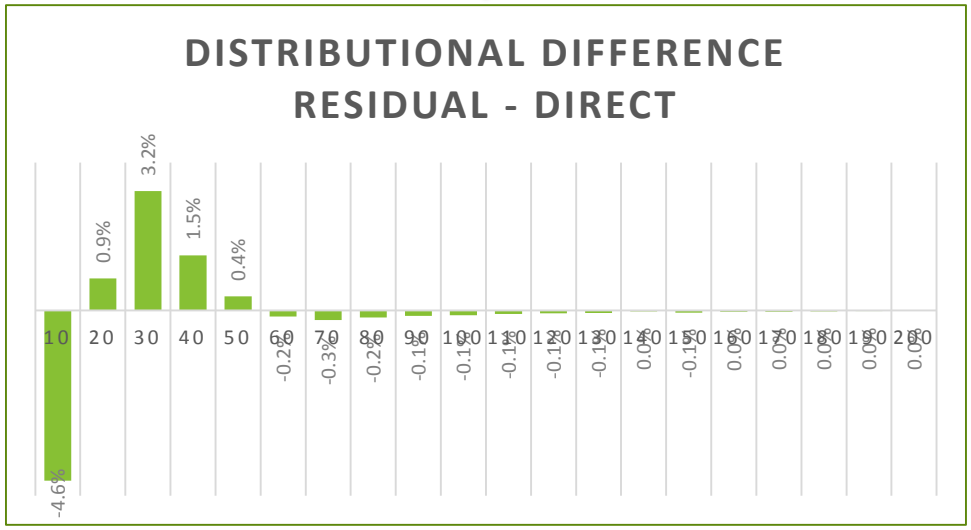
Direct Estimate



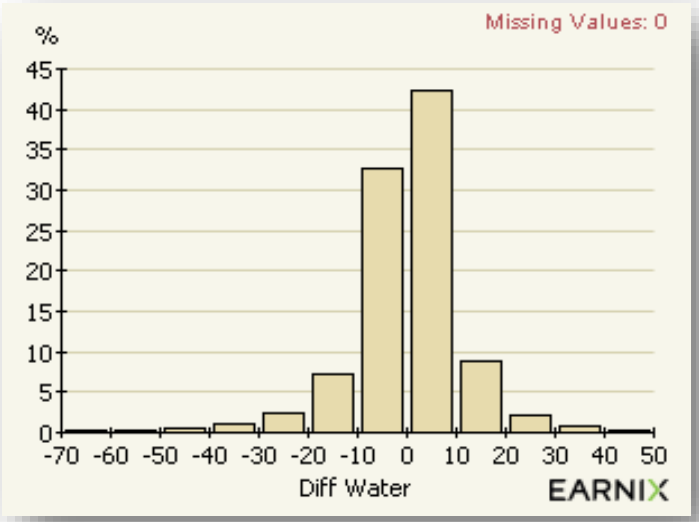
Comparison of Results – Water Peril



Range Analysis	Residual Modeling	Direct Estimation
1st Percentile	$6	$5
99th Percentile	$158	$168
Range (inner 98%)	$152	$163



50% exposures within +-$5



Comparison of Results – Combined Peril

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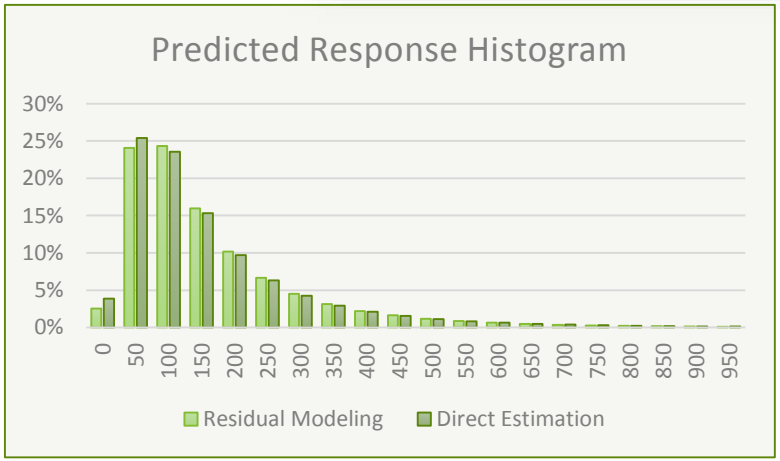
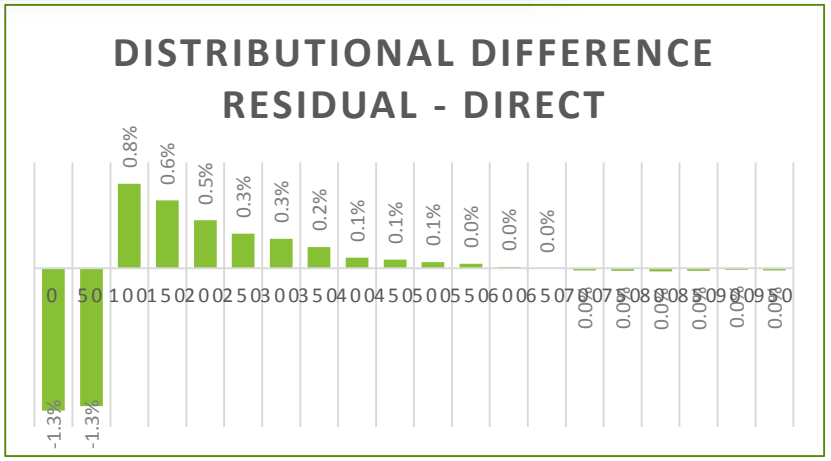
Statistics (from holdout)	Residual Modeling	Direct Estimation
1st Percentile	$42	$38
99th Percentile	$808	$872
Range (inner 98%)	$766	$834 (9%)





Additional segmentation is useless if segments do not result in <u>better risk classification</u>

Comparison of Results

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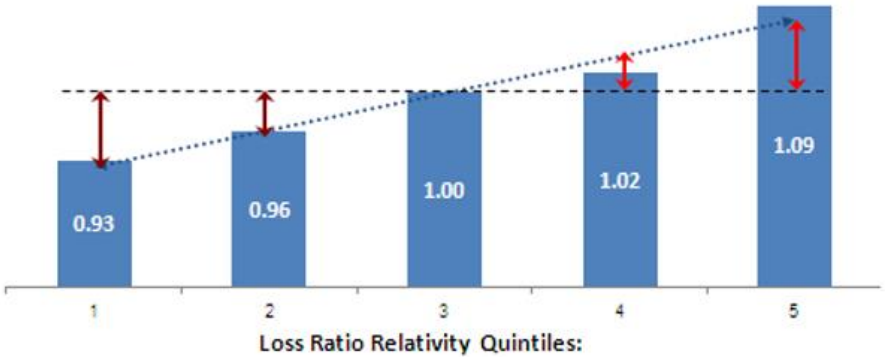
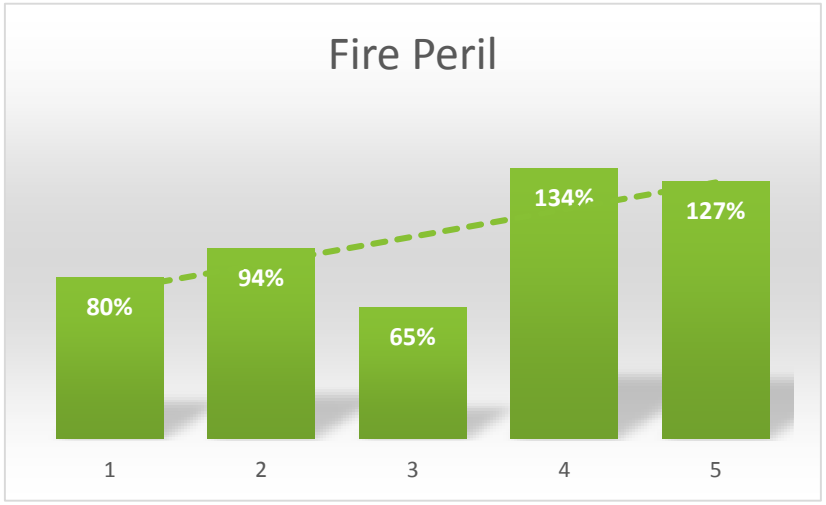
- Lift charts used to compare the results
- **Out-of-time** (2013) premiums were compared ~ Direct / Residual

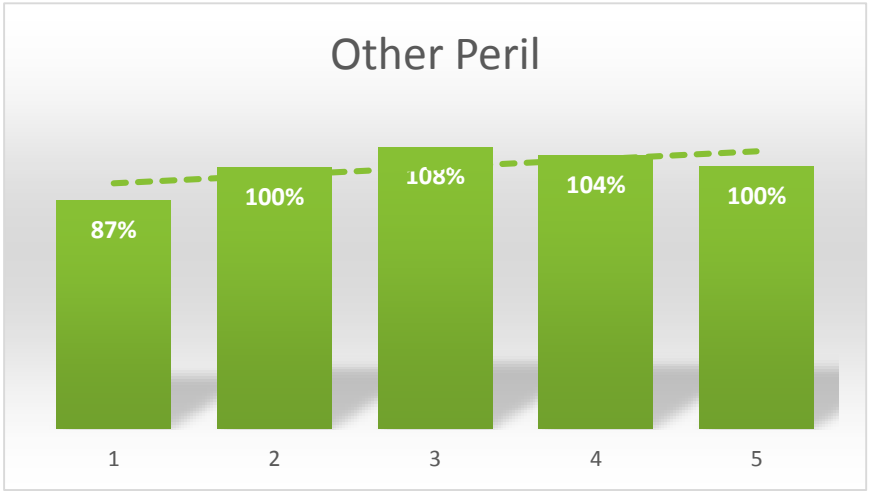


- The ordered values are bucketed into 5 equal exposure quintiles
- The loss ratio was then observed by comparing the observed losses to the current average premium within the group – Residual Premium
- Bars to the left depict where Direct Estimation approach predicts lower than Residual Estimation
- Bars to the right predicts higher than residual
- If direct estimation method provides lift, loss ratios should trend upward
- Lift is calculated as (Highest Quintile LR / Lowest Quintile LR – 1)

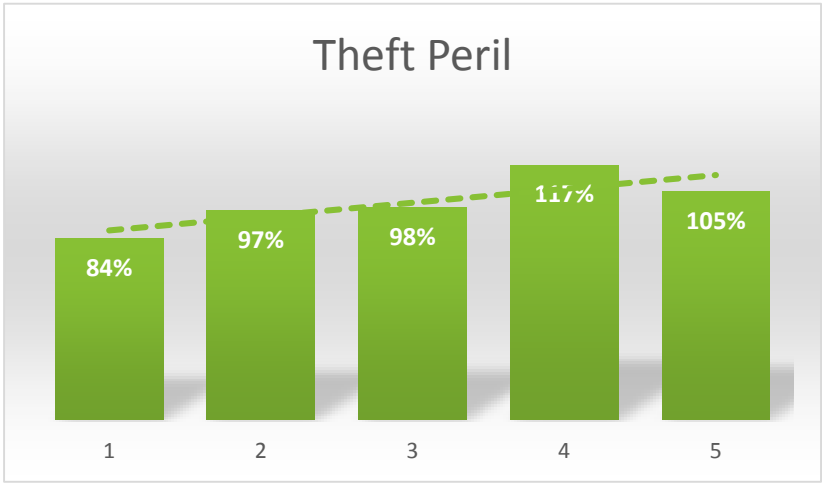
Lift Chart Analysis



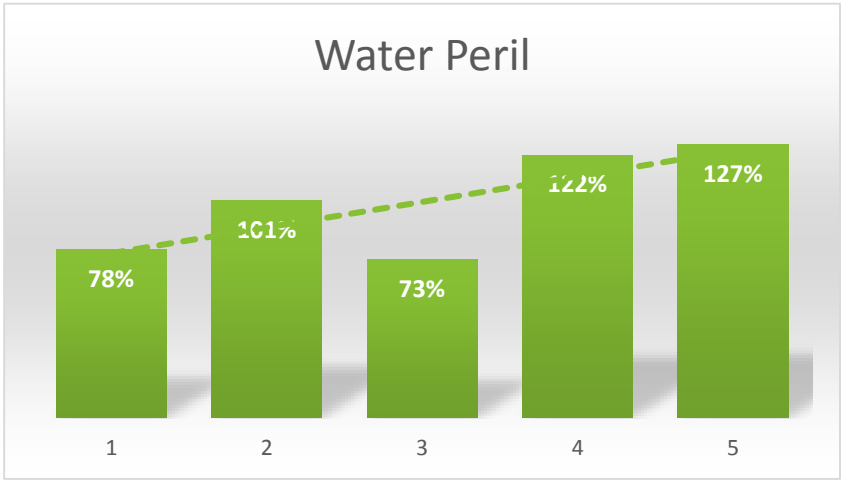
Fire Lift = (127% / 80%) – 1 = **80%**



Other Lift = (100% / 87%) – 1 = **15%**

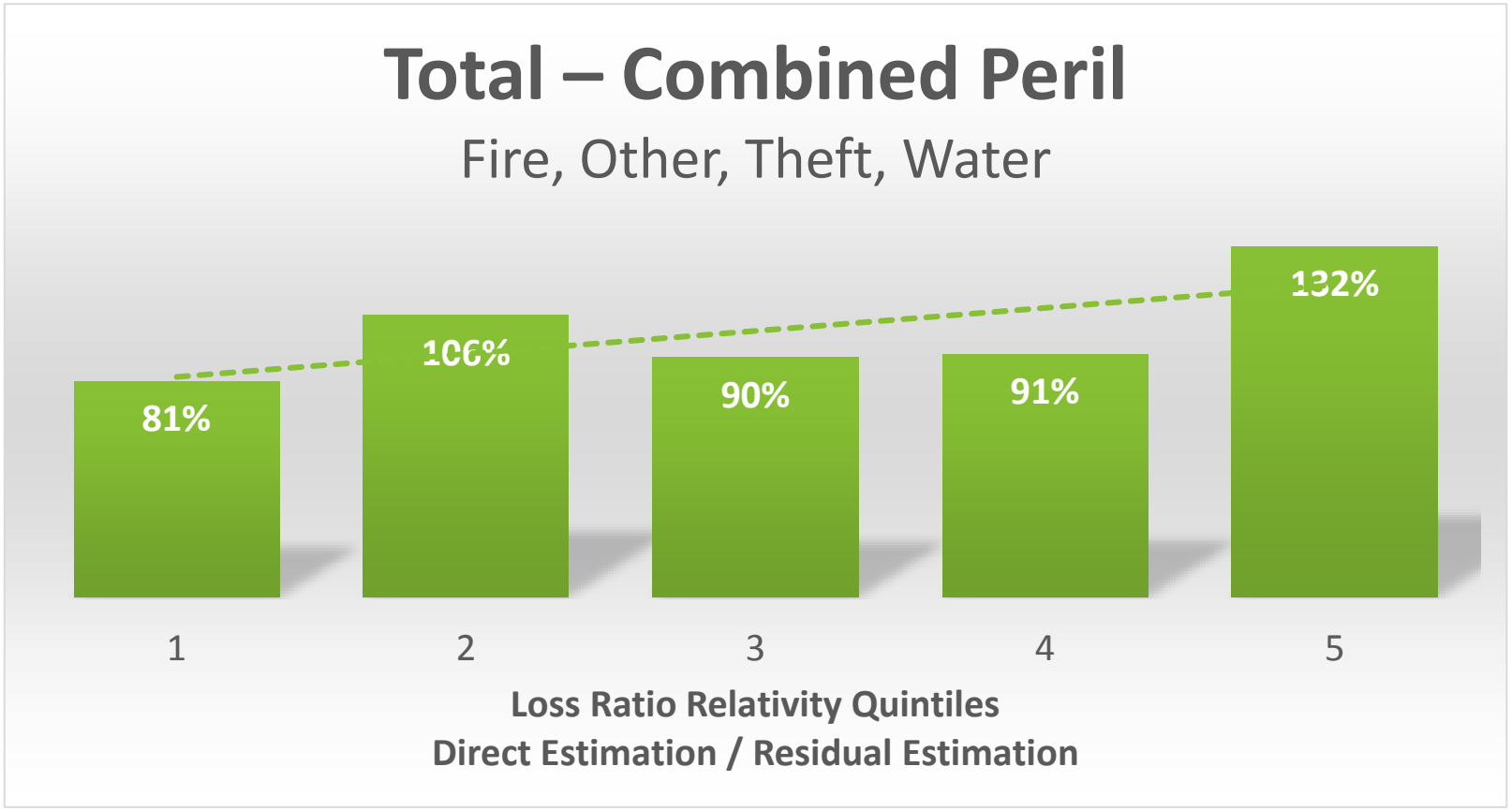


Theft Lift = (105% / 84%) – 1 = **25%**



Water Lift = (127% / 78%) – 1 = **62%**

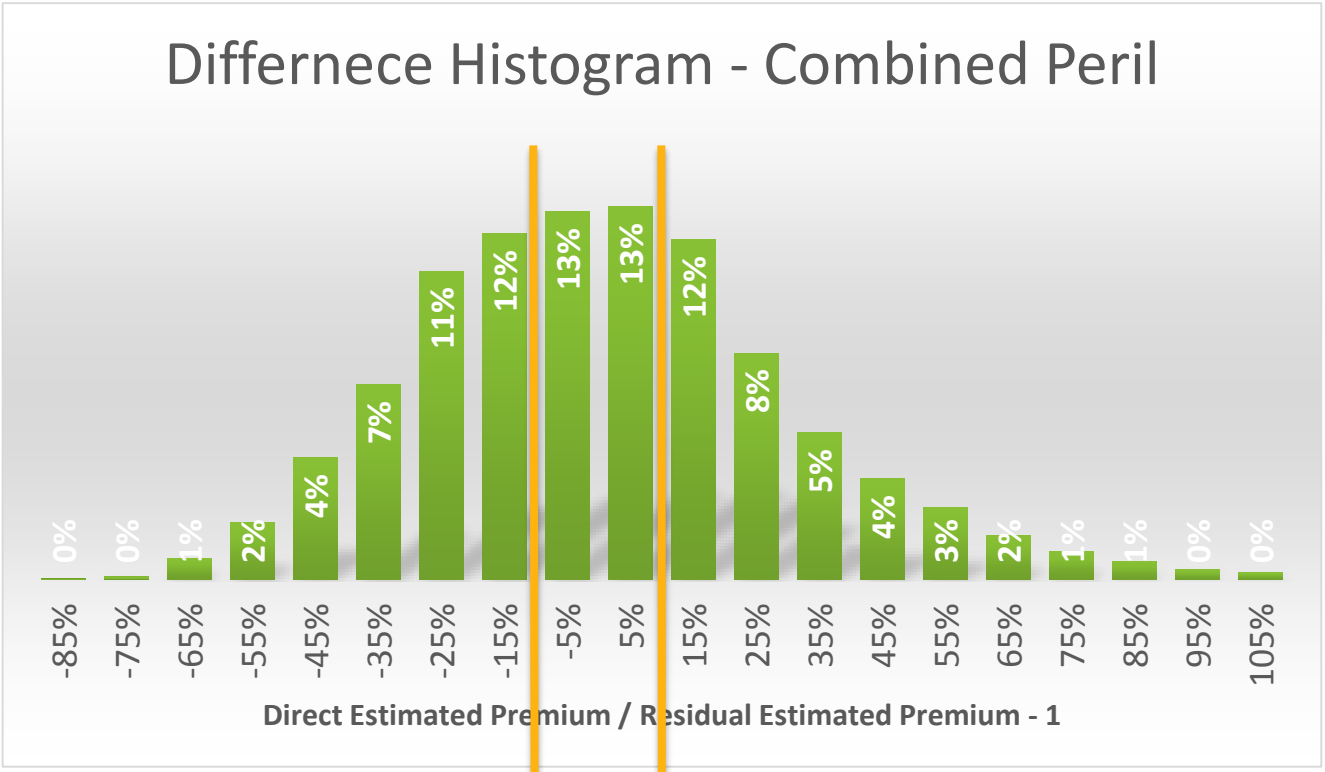
Lift Chart Analysis



Lift = (132% / 81%) – 1 = 63%

Positive, but not monotonic

Rate Comparison



Direct Approach

>10% Lower

LR = 99%

Residual Approach

>10% Lower

LR = 1.20%

Future Analysis

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- Out of time dataset limitations
  - Limited number of observations for homeowners modeling
  - Recent year has limited development (should be minimally bias with territory)
- Test factors without initial beta offset
  - Larger dataset required
  - Estimating geo and other factors simultaneously eliminates the need for PCA, thus simplifying the process more

Comparison of Results

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- Conclusion:
  - Both modeling techniques preform similarly on out-of-time sample

Residual Modeling	Direct Estimation
Long / complex process	Quick / simple process
2 weeks for analysis	2 days for analysis*
Less Segmentation	More Segmentation
Full control of process	Put faith into statistics
Results in a discrete territory groups	Results in an individual rate for each geo root level
GLM	GAM

*once initial process is defined

Thank You

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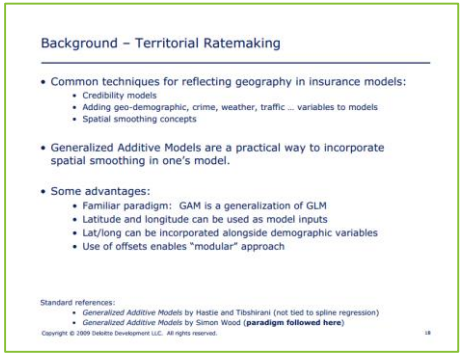
For complete Homeowners Insurance Ratemaking Applications Survey results, visit **earnix.com**

Additional Research

EARNIX


Background – Territorial Ratemaking

- Common techniques for reflecting geography in insurance models:
  - Credibility models
  - Adding geo-demographic, crime, weather, traffic … variables to models
  - Spatial smoothing concepts
- Generalized Additive Models are a practical way to incorporate spatial smoothing in one's model.
- Some advantages:
  - Familiar paradigm: GAM is a generalization of GLM
  - Latitude and longitude can be used as model inputs
  - Lat/long can be incorporated alongside demographic variables
  - Use of offsets enables "modular" approach

Standard references:
- *Generalized Additive Models* by Hastie and Tibshirani (not tied to spline regression)
- *Generalized Additive Models* by Simon Wood (**paradigm followed here**)

Deloitte.

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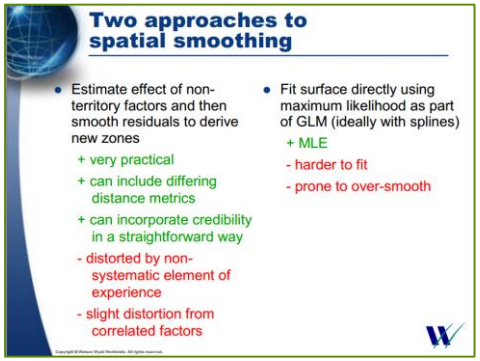
Geo-spatial Analysis with Generalized Additive Models

CAS Annual Meeting
Chicago
November, 2011

Jim Guszcza
Deloitte Consulting LLP
The University of Wisconsin-Madison


Two approaches to spatial smoothing

- Estimate effect of non-territory factors and then smooth residuals to derive new zones
  - + very practical
  - + can include differing distance metrics
  - + can incorporate credibility in a straightforward way
  - - distorted by non-systematic element of experience
  - - slight distortion from correlated factors
- Fit surface directly using maximum likelihood as part of GLM (ideally with splines)
  - + MLE
  - - harder to fit
  - - prone to over-smooth