



Firebird: Predicting Fire Risk and Prioritizing Fire Inspections in Atlanta

Collaboration of **Data Science for Social Good Atlanta** and **Atlanta Fire Rescue Department**

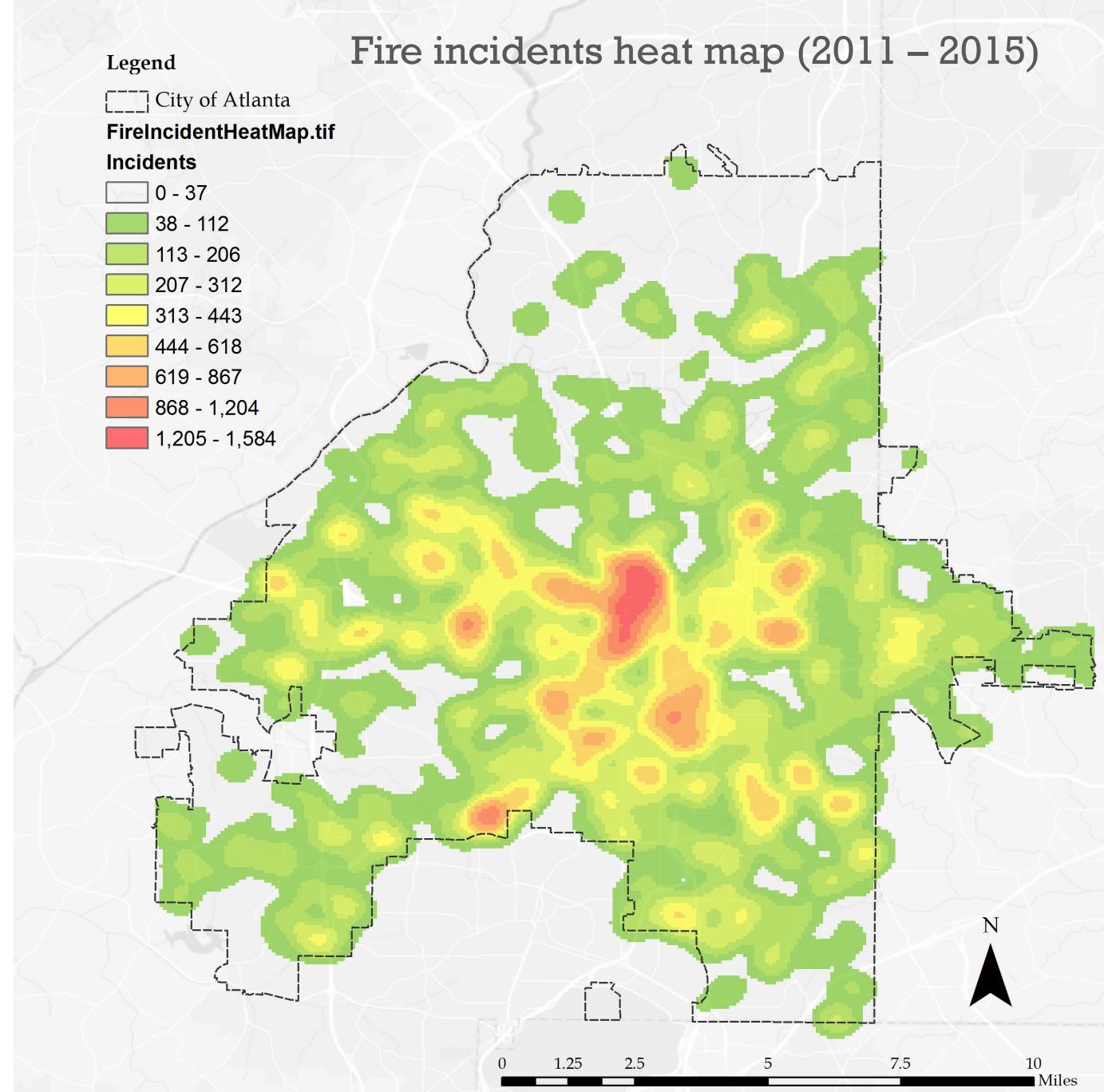
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Client	Dr. Matthew Hinds-Aldrich	Atlanta Fire Rescue Department
Advisors	Prof. Polo Chau Prof. Bistra Dilkina	Georgia Tech Georgia Tech



Problem

Hundreds of fires occur in Atlanta every year (like many other cities).

Only a small percentage of commercial properties were inspected annually by the Atlanta Fire Rescue Department (AFRD).



1) How do we help AFRD **identify** new properties that need inspection?

2) How do we help AFRD **prioritize** their property inspections by fire risk?

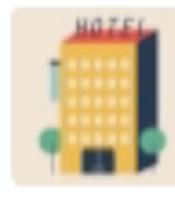
Fire incidents



Crime incidents



Socioeconomics & Demographics



Parcel Condition

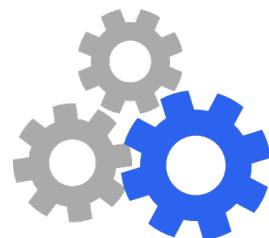


Fire Permits

Liquor & Business Licenses

Commercial Properties

Google Place API



Fire Risk Predictive Model (SVM, Random Forest)



Properties for Inspections



Interactive Map

Fire incidents, properties with risk scores



FIREBIRD
FRAMEWORK

Data

11 datasets

2+ GB

~200,000
Records

Data	Source
Fire Incident	 Atlanta Fire Department
Fire Inspection Permits	
Liquor License	
Parcel Data	
Atlanta Business Licenses	 City of Atlanta
Community Investment Report	
Neighborhood Planning Unit	Atlanta Regional Commission 
Demographic Data	 U.S. Census Bureau
Socio-economic Data	
CoStar Property Report	CoStar Group, Inc 
Business Location Data	Google APIs 

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Identifying potential inspections

Current Inspections



2,600



Business Licenses
20,000



- Find which licensed properties are currently inspected:
 - Cross-reference **current** inspections with larger datasets of commercial properties.

Google places

10,000

Identifying potential inspections

Current Inspections



2,600

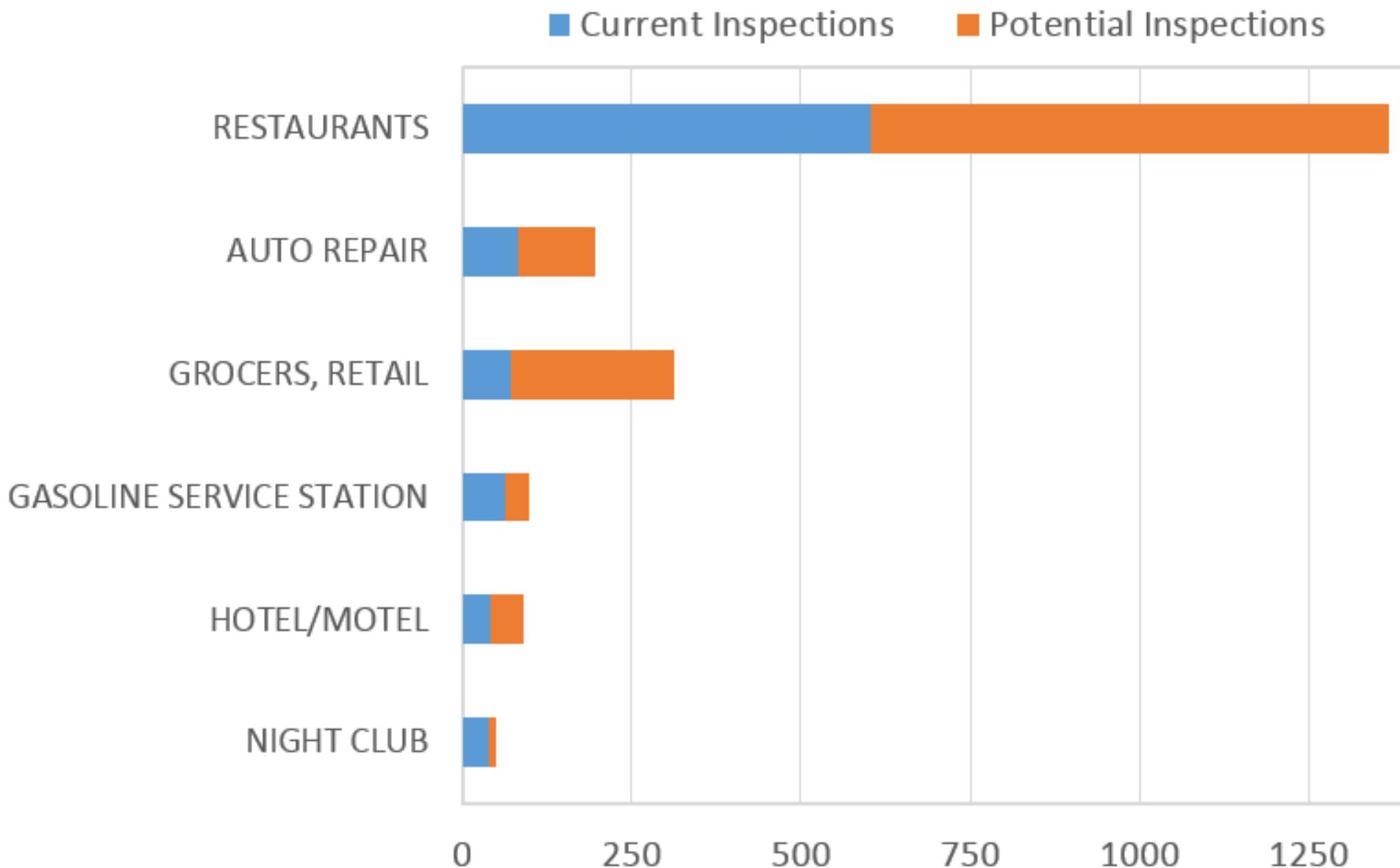


Google places

10,000

- Find which licensed properties are currently inspected.
- Find similar property types:
 - Geocoding of addresses
 - Fuzzy text-matching (“McDonalds” vs “MacDonald’s”)
- Generate unique property list

Identifying potential inspections



Top 6 currently inspected property types

Inspection List

List of 8,669 properties

- Current Inspections: 2,573
- **New potential Inspections: 6,096**
- Only using the top 100 currently inspected property types

Property Information:

- Name, address, phone, business type
- Lookup ID's - Business License ID, Google ID, Liquor License ID
- Fire risk scores

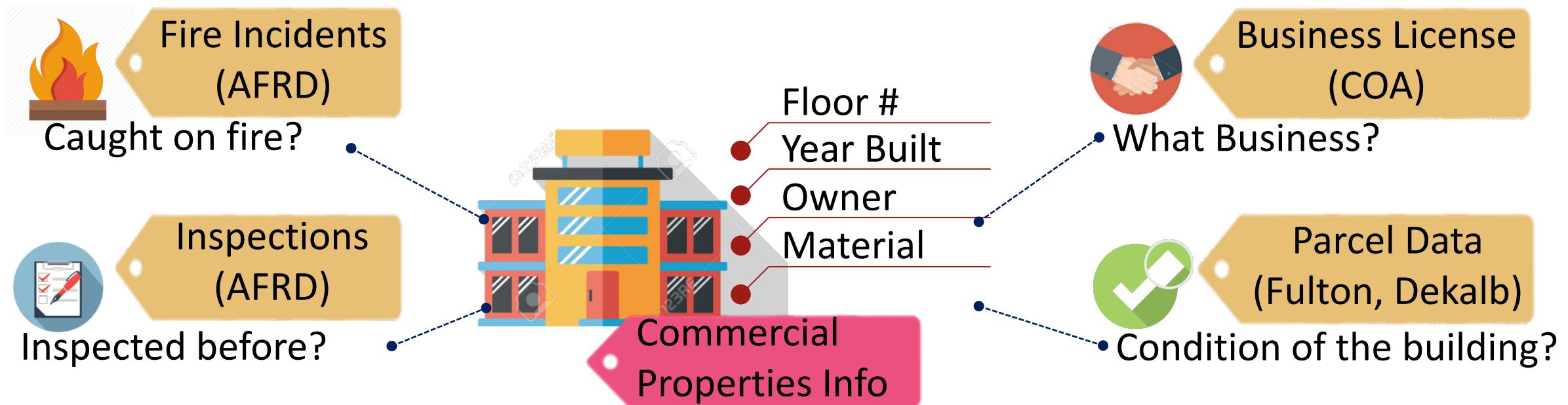
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2) How do we help AFRD **prioritize** their property inspections by fire risk?

Fire Risk Predictive Model

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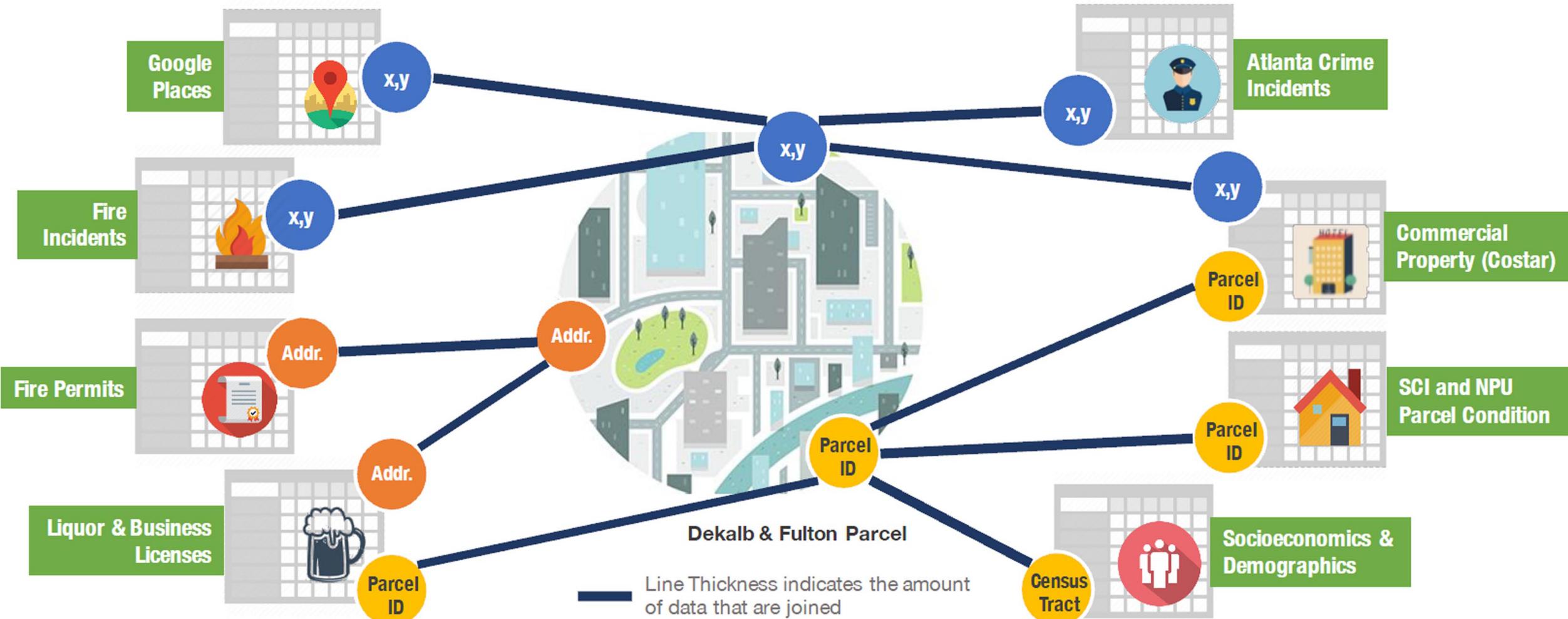
- Data from various sources



How do we **CONNECT** data from various sources together, so that they can talk to each other?

Fire Risk Predictive Model

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Fire Risk Predictive Model

Example of joined dataset

Property ID	Floor	Year Built	Material	Renovation year	Land Use	Lot Condition	Structure Condition	Employment Density (per Sq Mi)	Inspection	Previous Fire
41815	20	1929	Masonry	2006	Office	Good	Fair	1291.3	0	0
7381715	11	1972	Wood Frame	-	Garden Apartment	Poor	Deteriorated	107.3	1	7

Commercial Property
(Costar)

Parcel Data

Community Survey
(City of Atlanta)

US Census

Fire Records
(AFRD)

252 Variables describing different aspects of each property

Fire Risk Predictive Model

Data:

- $N = 8,223$ commercial properties, with 493 fires from 2011-2015
- Use data in 2011~2014 to predict fires in 2015

Preprocessing (**252** raw variables → **1127** processed features):

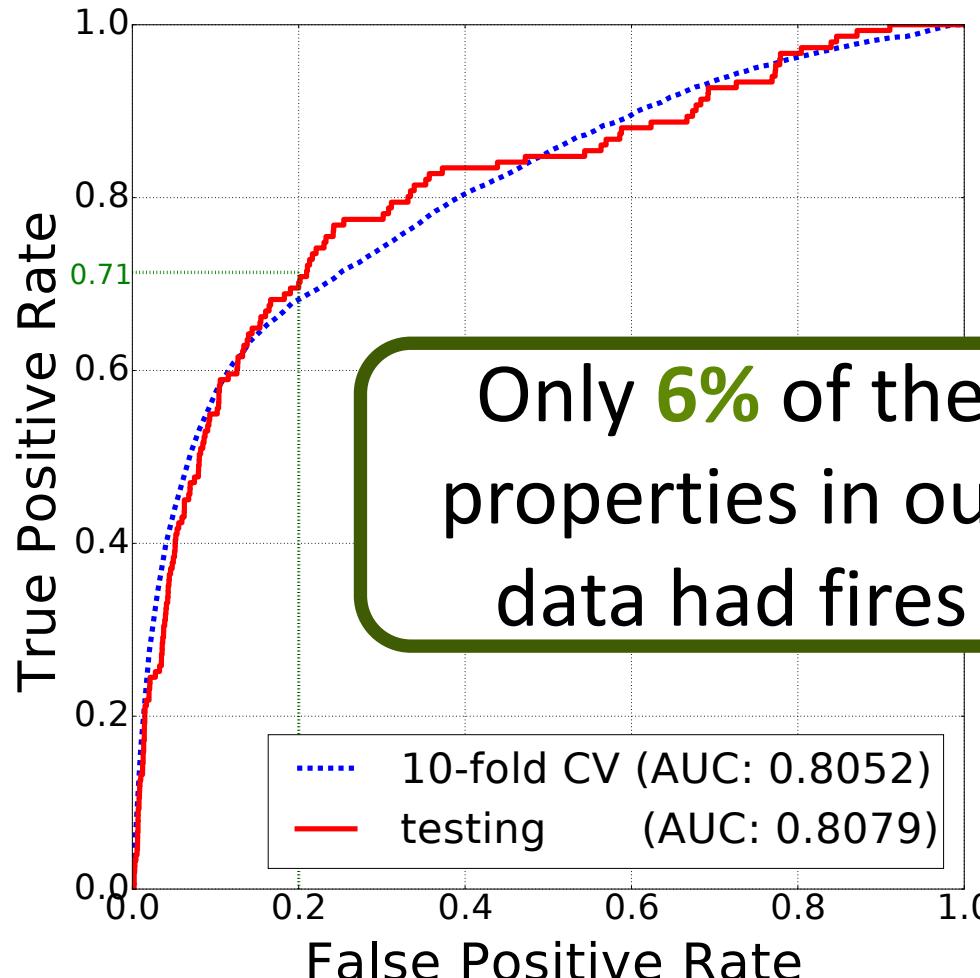
- Forwards and backwards feature selection to select 58 predictive variables
- Filled in missing values with 0, and added another binary feature (1 if missing)
- Expanded categorical variables into binary features
- Normalized numerical variables to [0,1]
 - For large numerical variables (e.g., sale price), used log transformation first

Models:

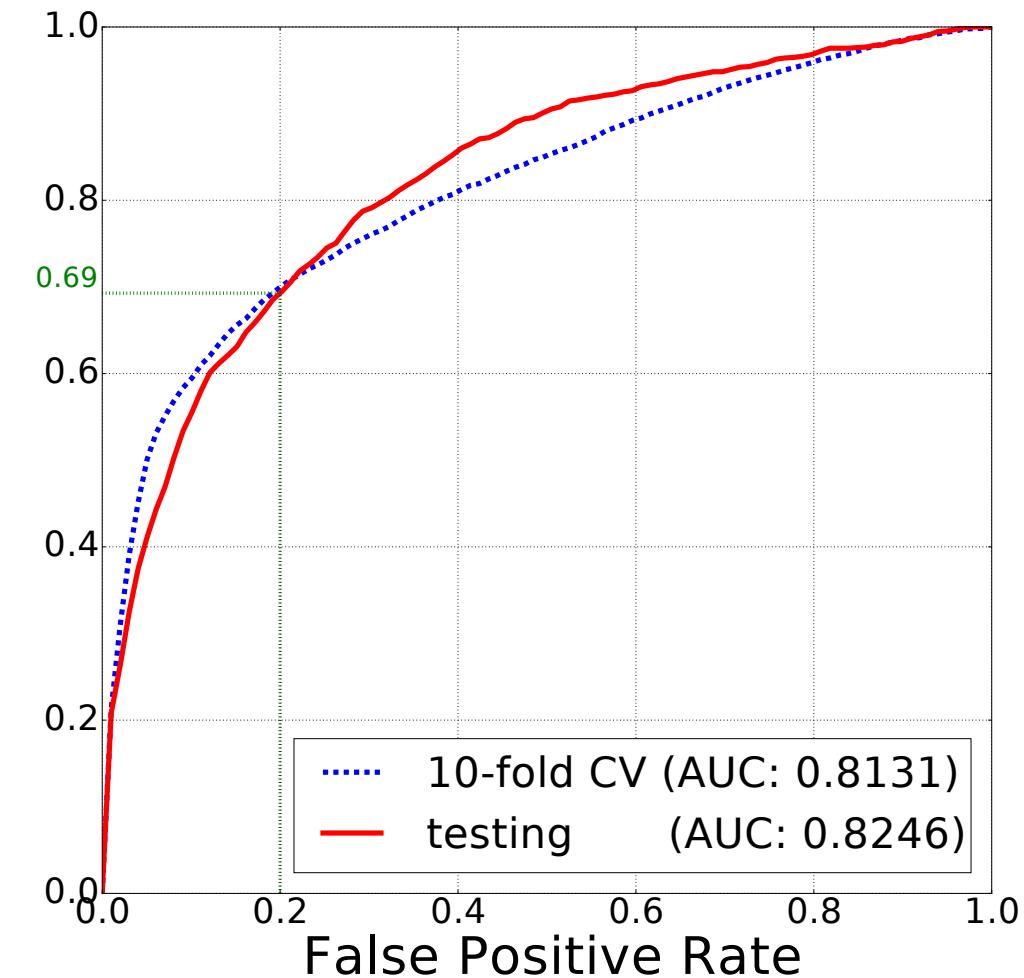
- **SVM** and **Random Forest** perform best
- Also tried Logistic Regression and Gradient Boosting Tree

Experiment results

SVM: predict **71%** of fires
(at 20% FPR)



Random Forest: predict **69%** of fires
but with a higher overall AUC



Predicting fires in different time periods

- Accuracy is consistent in predicting different years
 - Except for single-year 2011-2012 training window

Training window	Random Forest	SVM
2011-2012	0.7624	0.7614
2011-2013	0.8030	0.7914
2011-2014	0.8246	0.8079

Top 10 Features (Random Forest Model)

1. floor size
2. land area
3. number of units
4. appraised value
5. number of building
6. total taxes
7. property type: multi-family
8. lot size
9. number of living units
10. percent leased

Intuition

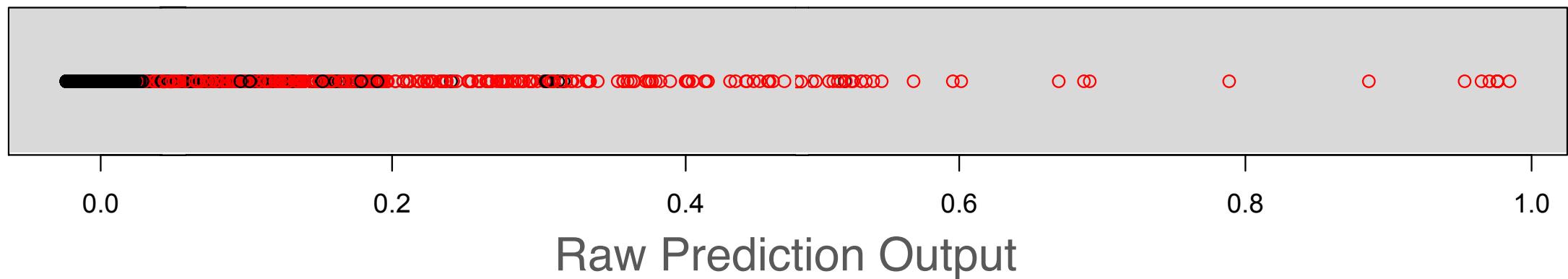
Buildings of

- larger size
 - containing more units
- would have higher probability
of catching fire.

Applying Predictive Model to Fire Inspections

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- True Positive
- True Negative



Applying Predictive Model to Fire Inspections

A	B	C	D	E	F	G	H	I
name	address	phone	occup_type	b_sic_desc	google_type	fire_risk_rating	risk_category	
123 Main St, Anytown, USA	123-555-1234	(555) 123-4567	NIGHTCLUB	RESTAURANTS	NA	1	low risk	
456 Elm St, Anytown, USA	123-555-1234	(555) 123-4567	RESTAURANT	RESTAURANTS	RESTAURANT	NA	NA	
789 Oak St, Anytown, USA	123-555-1234	(555) 123-4567	RESTAURANT	RESTAURANTS	RESTAURANT	NA	1	low risk
111 Pine St, Anytown, USA	123-555-1234	(555) 123-4567	RESTAURANT	RESTAURANTS	BAR	NA	1	low risk
222 Cedar St, Anytown, USA	123-555-1234	(555) 123-4567	RESTAURANT	RESTAURANTS	NA	NA	1	low risk
333 Birch St, Anytown, USA	123-555-1234	(555) 123-4567	RESTAURANT	RESTAURANTS	BAR	NA	1	low risk
555 Chestnut St, Anytown, USA	123-555-1234	(555) 123-4567	NIGHTCLUB	RESTAURANTS	NIGHT_CLUB	NA	1	low risk
666 Locust St, Anytown, USA	123-555-1234	(555) 123-4567	RESTAURANT	RESTAURANTS	BAR	NA	1	low risk
888 Willow St, Anytown, USA	123-555-1234	(555) 123-4567	NIGHTCLUB	RESTAURANTS	BAR	NA	2	medium risk
999 Hickory St, Anytown, USA	123-555-1234	(555) 123-4567	NIGHTCLUB	NA	NA	NA	NA	
1010 Chestnut St, Anytown, USA	123-555-1234	(555) 123-4567	NIGHTCLUB	RESTAURANTS	RESTAURANT	NA	1	low risk
1111 Locust St, Anytown, USA	123-555-1234	(555) 123-4567	RESTAURANT	RESTAURANTS	RESTAURANT	NA	1	low risk
1212 Hickory St, Anytown, USA	123-555-1234	(555) 123-4567	RESTAURANT	RESTAURANTS	RESTAURANT	NA	1	low risk
1313 Chestnut St, Anytown, USA	123-555-1234	(555) 123-4567	RESTAURANT	RESTAURANTS	RESTAURANT	NA	NA	
1414 Locust St, Anytown, USA	123-555-1234	(555) 123-4567	NIGHTCLUB	RESTAURANTS	BAR	NA	1	low risk
1515 Hickory St, Anytown, USA	123-555-1234	(555) 123-4567	RESTAURANT	RESTAURANTS	BAR	NA	NA	
1616 Chestnut St, Anytown, USA	123-555-1234	(555) 123-4567	NIGHTCLUB	RESTAURANTS	RESTAURANT	NA	1	low risk
1717 Locust St, Anytown, USA	123-555-1234	(555) 123-4567	RESTAURANT	RESTAURANTS	CAFE	NA	2	medium risk
1818 Hickory St, Anytown, USA	123-555-1234	(555) 123-4567	RESTAURANT	RESTAURANTS	RESTAURANT	NA	NA	
1919 Chestnut St, Anytown, USA	123-555-1234	(555) 123-4567	RESTAURANT	RESTAURANTS	RESTAURANT	NA	NA	
2020 Locust St, Anytown, USA	123-555-1234	(555) 123-4567	RESTAURANT	RESTAURANTS	BAR	NA	NA	
2121 Hickory St, Anytown, USA	123-555-1234	(555) 123-4567	RESTAURANT	RESTAURANTS	NA	NA	1	low risk

Applying Predictive Model to Fire Inspections

A	B	C	D	E	F	G	H	I	J
name	address	phone	occ_type	fire_risk_rating	risk_category	rating	risk_category		
1	1	1	NIC	8	high risk	1	low risk		
2	2	2	RES	8	high risk	NA			
3	3	3	RES	8	high risk	1	low risk		
4	4	4	RES	8	high risk	1	low risk		
5	5	5	RES	8	high risk	1	low risk		
6	6	6	RES	8	high risk	1	low risk		
7	7	7	NIC	8	high risk	1	low risk		
8	8	8	RES	8	high risk	1	low risk		
9	9	9	NIC	8	high risk	1	low risk		
10	10	10	NIC	8	high risk	2	medium risk		
11	11	11	NA						
12	12	12	1	low risk					
13	13	13	1	low risk					
14	14	14	1	low risk					
15	15	15	NA						
16	16	16	1	low risk					
17	17	17	NA						
18	18	18	1	low risk					
19	19	19	1	low risk					
20	20	20	2	medium risk					
21	21	21	NA						
22	22	22	NA						
23	23	23	1	low risk					
24	24	24	NA						
25	25	25	1	low risk					
26	26	26	1	low risk					
27	27	27	NA						
28	28	28	NA						
29	29	29	2	medium risk					
30	30	30	NA						
31	31	31	NA						
32	32	32	NA						
33	33	33	NA						
34	34	34	NA						
35	35	35	NA						
36	36	36	NA						
37	37	37	NA						
38	38	38	NA						
39	39	39	NA						
40	40	40	NA						
41	41	41	NA						
42	42	42	NA						
43	43	43	NA						
44	44	44	NA						
45	45	45	NA						
46	46	46	NA						
47	47	47	NA						
48	48	48	NA						
49	49	49	NA						
50	50	50	NA						
51	51	51	NA						
52	52	52	NA						
53	53	53	NA						
54	54	54	NA						
55	55	55	NA						
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64	64	64	NA						
65	65	65	NA						
66	66	66	NA						
67	67	67	NA						
68	68	68	NA						
69	69	69	NA						
70	70	70	NA						
71	71	71	NA						
72	72	72	NA						
73	73	73	NA						
74	74	74	NA						
75	75	75	NA						
76	76	76	NA						
77	77	77	NA						
78	78	78	NA						
79	79	79	NA						
80	80	80	NA						
81	81	81	NA						
82	82	82	NA						
83	83	83	NA						
84	84	84	NA						
85	85	85	NA						
86	86	86	NA						
87	87	87	NA						
88	88	88	NA						
89	89	89	NA						
90	90	90	NA						
91	91	91	NA						
92	92	92	NA						
93	93	93	NA						
94	94	94	NA						
95	95	95	NA						
96	96	96	NA						
97	97	97	NA						
98	98	98	NA						
99	99	99	NA						
100	100	100	NA						

Fire Incidents

Choose a Fire Incident Type...

1-2011

1-2016

Current Inspections

Choose an Inspection Type...

9-2012

1-2015

Potential Inspections

Choose a Potential Inspection Type...

Low Risk

Medium Risk

High Risk

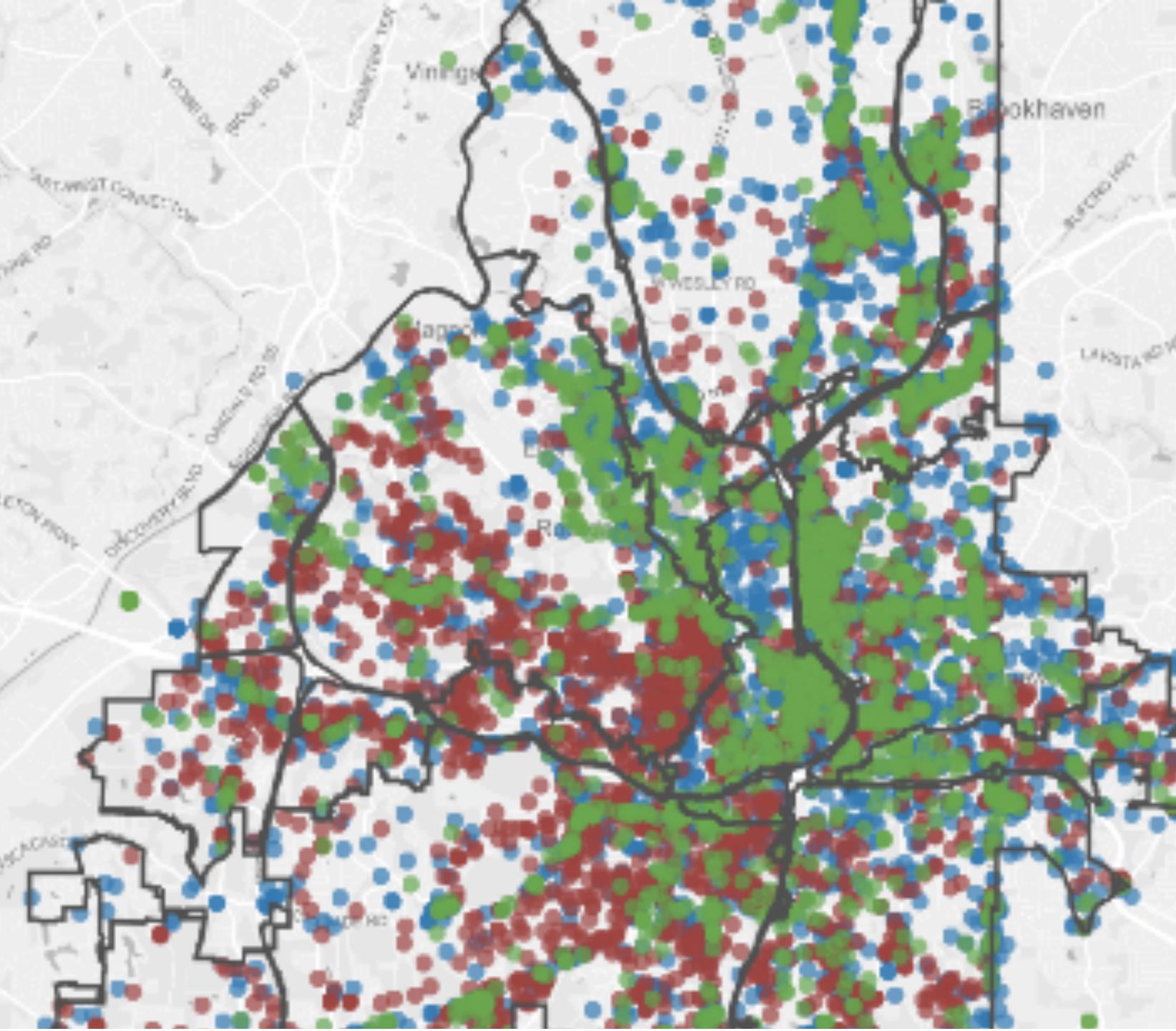
No Overlay

Battalions

NPU

Council Districts

Reset Filters



Fire Incidents: 73

RESTAURANT (73)

1-2011

1-2016

Current Inspections: 782

RESTAURANT (782)

1-2012

1-2015

Potential Inspections: 1235

RESTAURANTS (1235)

Low Risk Medium Risk

High Risk

No Overlay

Battalions

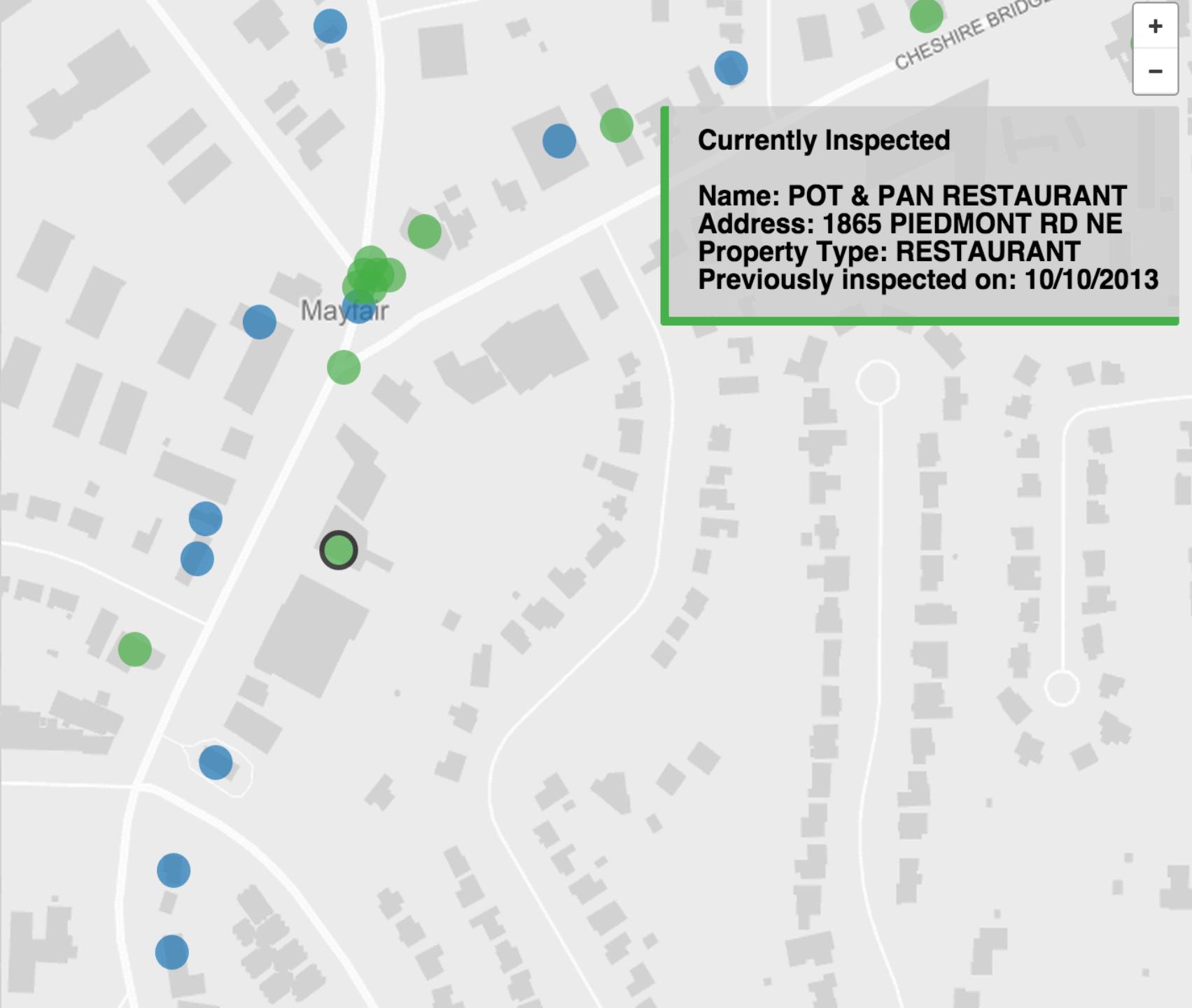
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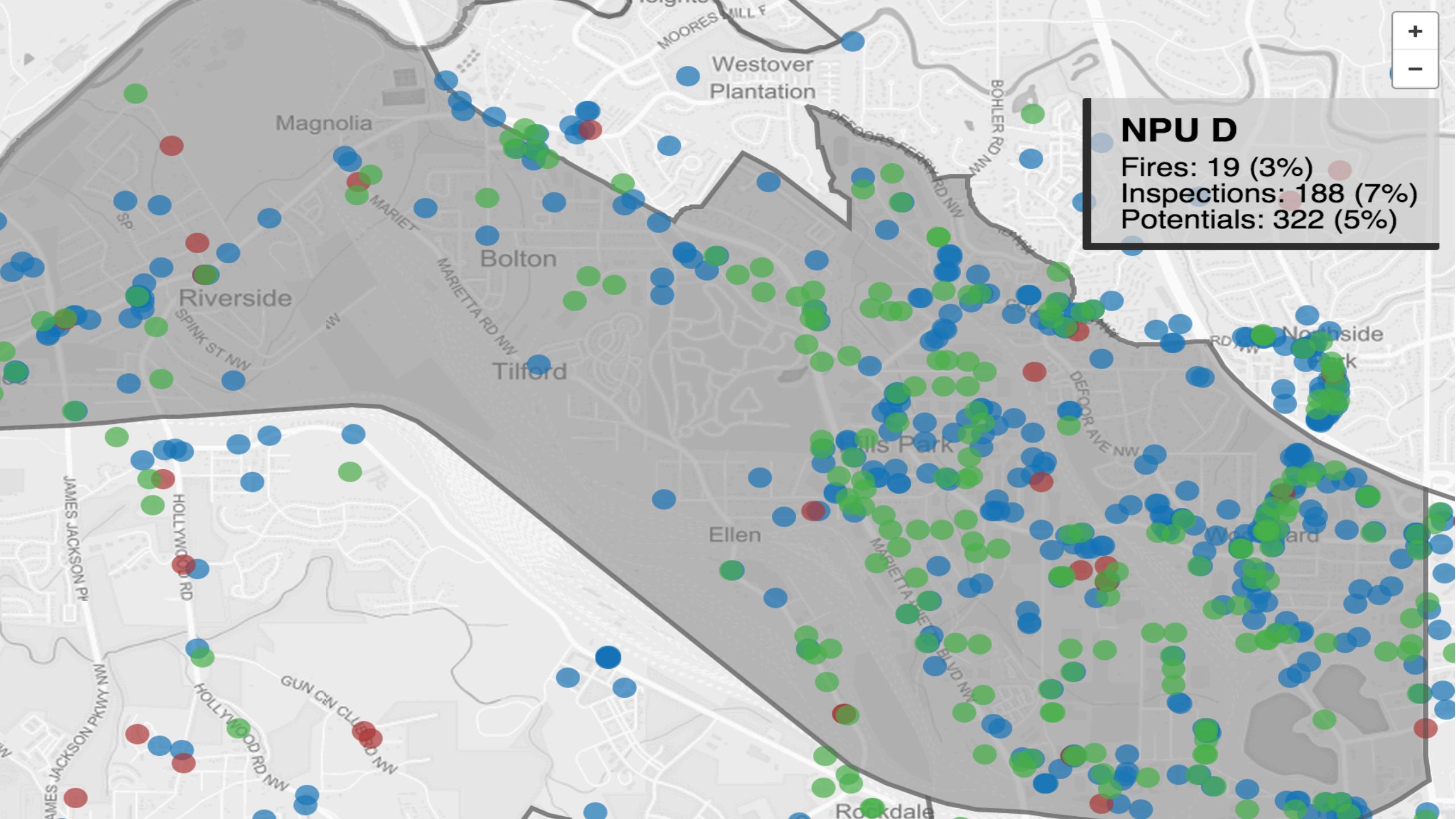


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NPU D

Fires: 19 (3%)
Inspections: 188 (7%)
Potentials: 322 (5%)



Tech Transfer to AFRD

Database of 6,096 new properties requiring inspection

Predictive model for fires in 5,022 properties

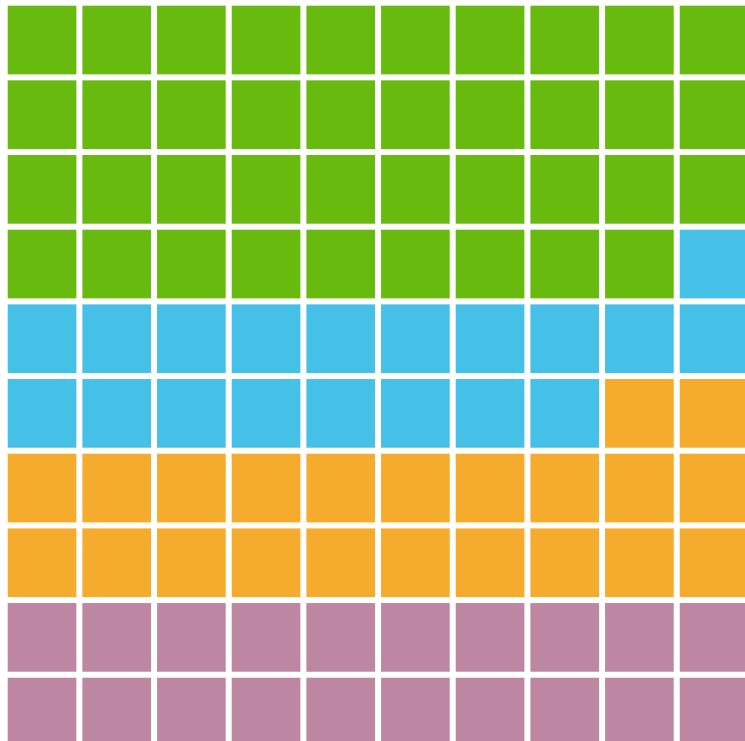
- At false positive rate of 20%
- SVM predicts 71.36% of fires
- Random Forest predicts 69.28% of fires

Interactive map to view fires, current inspections, and potential inspections

Impact on AFRD Inspections

69 high risk properties assigned for inspection

48 fire safety violations found



27 out-of-date permits

13 required new permits

15 out of business

14 required no permits

Impact on AFRD Planning

Informing fire safety personnel allocation

Improving data sharing across municipal departments

Reforming fire code inspection policy

Highlighted by the National Fire Protection Association as a **best practice** for using data to improve fire safety practices.

Future Work

Improve the models by using behavioral data about property usage.

Extend the models to be applicable to more properties in the city.

Integrate permit violation data into firefighters' data dashboards.

We encourage municipal fire safety organizations to use the Firebird framework to **identify** and **prioritize** property inspections.



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