Role of Innovative Resource Recovery Approaches in the Resilience of Cities

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RESILIENCE

THE CAPACITY OF (……) TO MAINTAIN AND PROVIDE ESSENTIAL FUNCTIONS AND SERVICES DURING AND IMMEDIATELY FOLLOWING CONVENTIONAL OR RARE DISRUPTIONS

ACUTE DISRUPTIONS

Earthquakes

Wildfires
Severe Storms
Extreme Precipitation
Disease Outbreaks
Civil Unrest
Infrastructure Failure
Building Collapse/Fire
Heat Waves
Railroad Accidents
Terrorism

Flooding

LONG TERM DISRUPTIONS

Drought

- Lack of Fresh Water
- Aging Infrustructure (roads, bridges, etc)
- Poverty (low income)
- Unemployment
- Crime
- Homelessness
- Lack of Affordable Housing

Air Pollution

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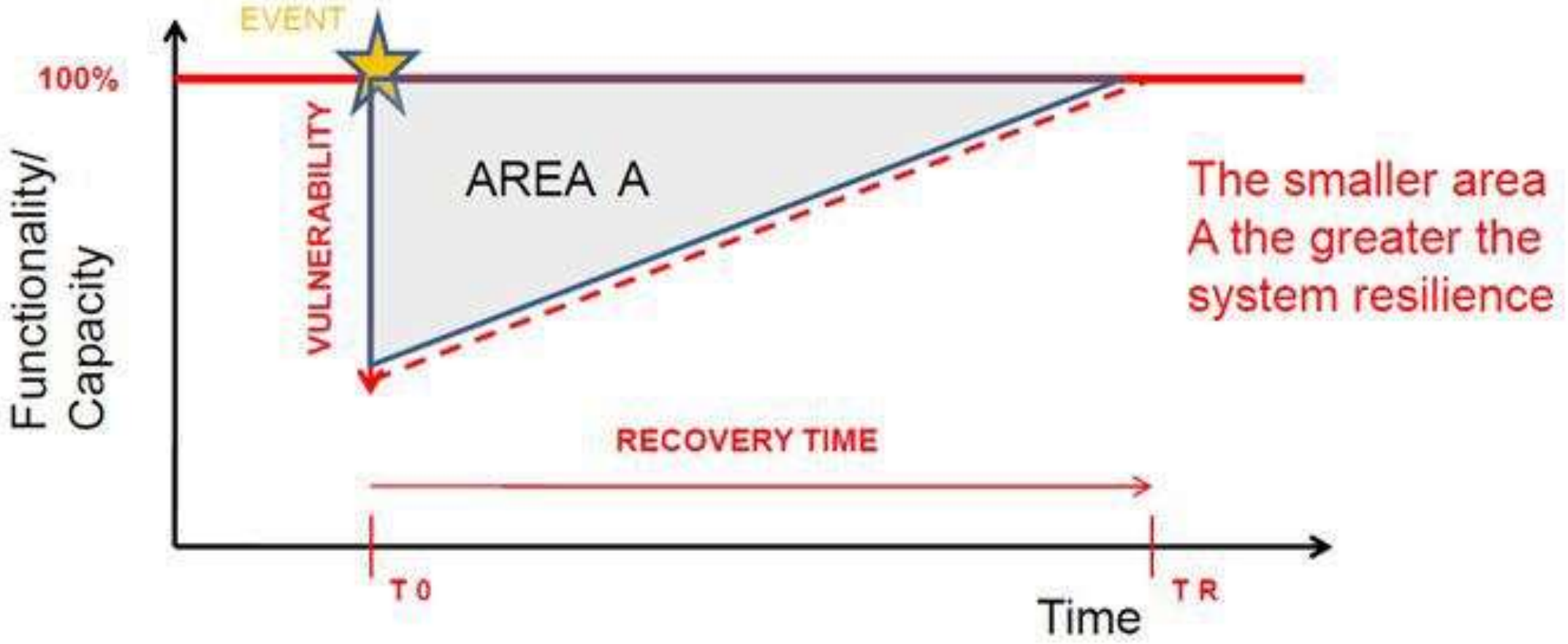


Dr James Kimmance, Infrastructure Risk & Resilience: BCI Workshop, Bristol 2010

RESILIENCE

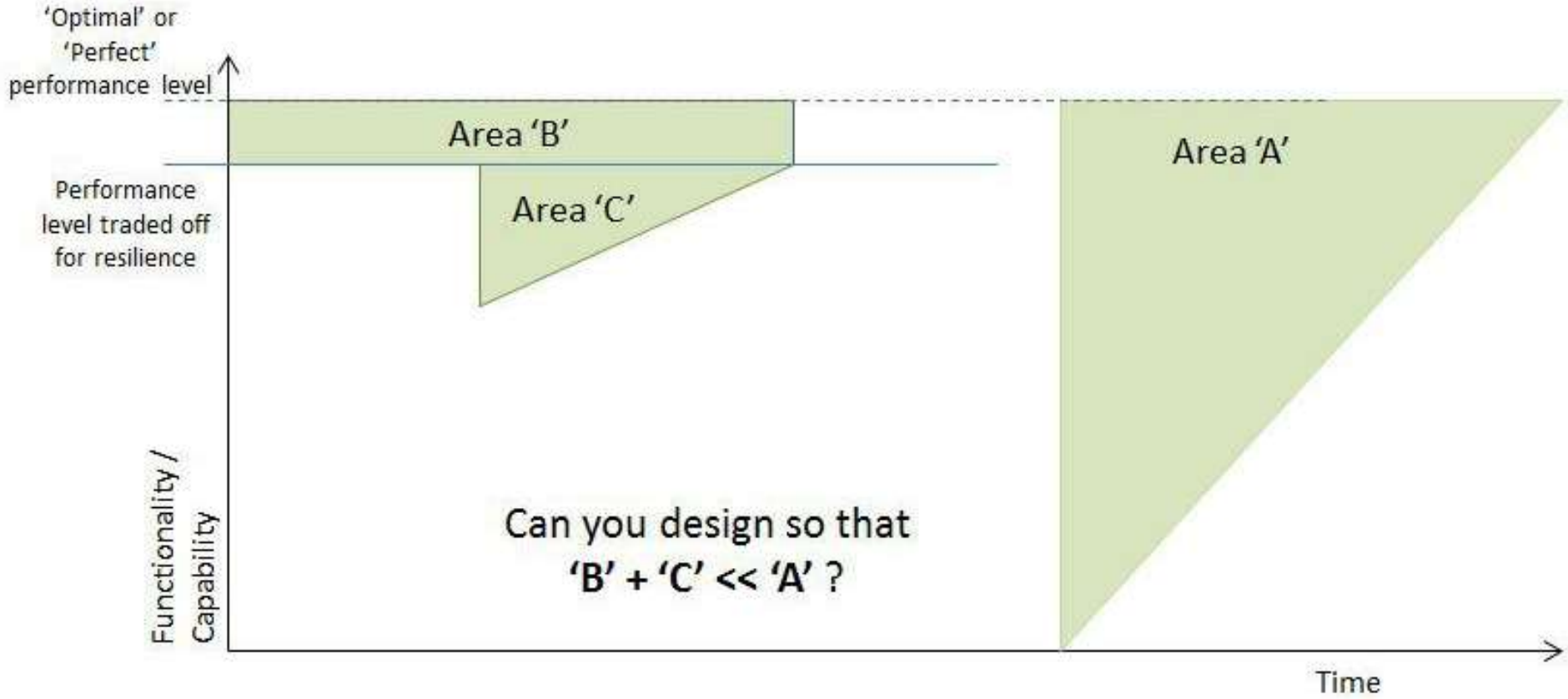
The National Institute of Standards is looking at the issue in terms of

providing resilience to an entire community

Thus resilience can be related to

- a single structure say a building or a bridge,
- a portfolio of structures, a wastewater treat plant
- all aspects of one utility, i.e. the solid waste management system, water supply system, public health services
- an entire city, accounting for all aspects of the life of the city including all utilities, all portfolios including the interruption to business and daily life.
- .....

RESILIENCE



One might choose to redesign or operate the system at some level below its theoretical optimum in exchange for improved resilience. In other words, there's an enduring sacrifice of performance (Area 'B' in the diagram above).

However, system resilience is improved, represented by a smaller triangle (Area 'C') compared with that of a system optimised for normal operation (Area 'A').

RESILIENCE

In scenarios where you want to combine different types of services, many people use “utility functions” to express lack of functionality in monetary units i.e. “dollars”.

The formulation of the utility function depends upon the type of functionality and the operational aspects of the entity in question.

THE UTILITY FUNCTION

GENERAL

Total Annual Expenditures = (a + b + c + d + e + f + g) x TAR

TAR = Total annual revenue ($)
a….g = Fraction of total annual revenue (TAR) for each specific operational component

Define Each Component and Develop its Utility Function

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Hypothetical Example

Consider an integrated solid waste management agency –

The services it typically provides include (OPERATIONS COMPONENT)

a) Curbside collection of source separated municipal solid wastes – once or twice a week. (CCSSMSW)
b) Curbside collection of source separated recyclables – newspapers and GMP – once a week (CCSSR)
c) Bulk curbside pick up – once a month (BCP)
d) Yard waste collection – composting – mostly high rate windrows
e) Street cleaning services
f) Special Projects – kept under a single title

THE UTILITY FUNCTION

RESEARCH THE UTILITY FUNCTION FOR (a) CCSSMSW

CCSSMSW = TOTAL TONS COLLECTED / DAY

First Selected Performance Index = Tonnage Collected

This step requires weighing or a method of estimating the weight of material collected each day.

Record the tonnage collected in each of the 104 collections in a year. (52 weeks x 2 collections/week)

Plot the actual collection day (x-axis) versus the tons collected (y-axis) as a trend analysis.

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Hypothetical Example of Implementation of the Utility Function Analysis of Data Collected During CCSSMSW

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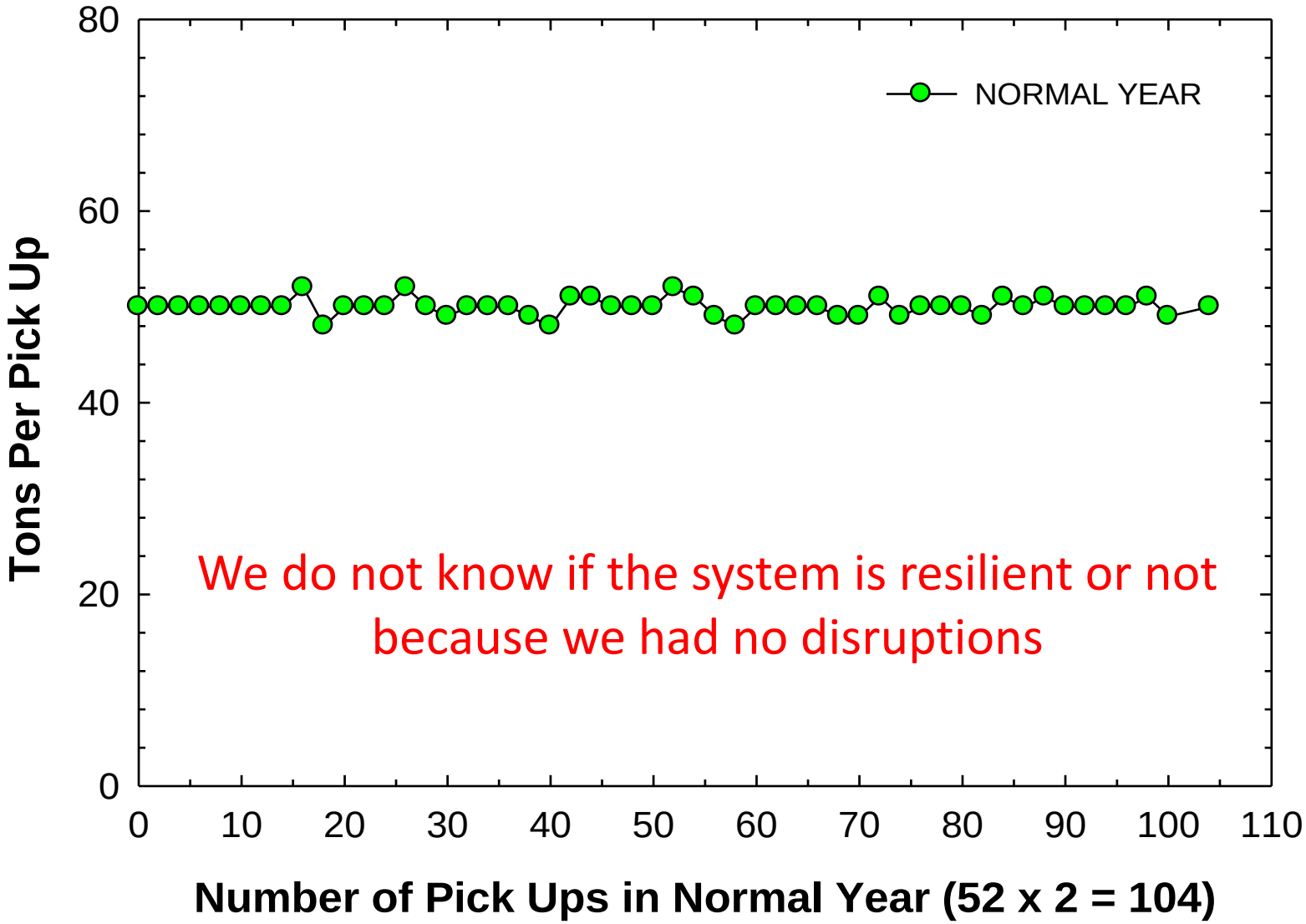

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Hypothetical Example of Implementation of the Utility Function

Analysis of Data Collected During CCSSMSW

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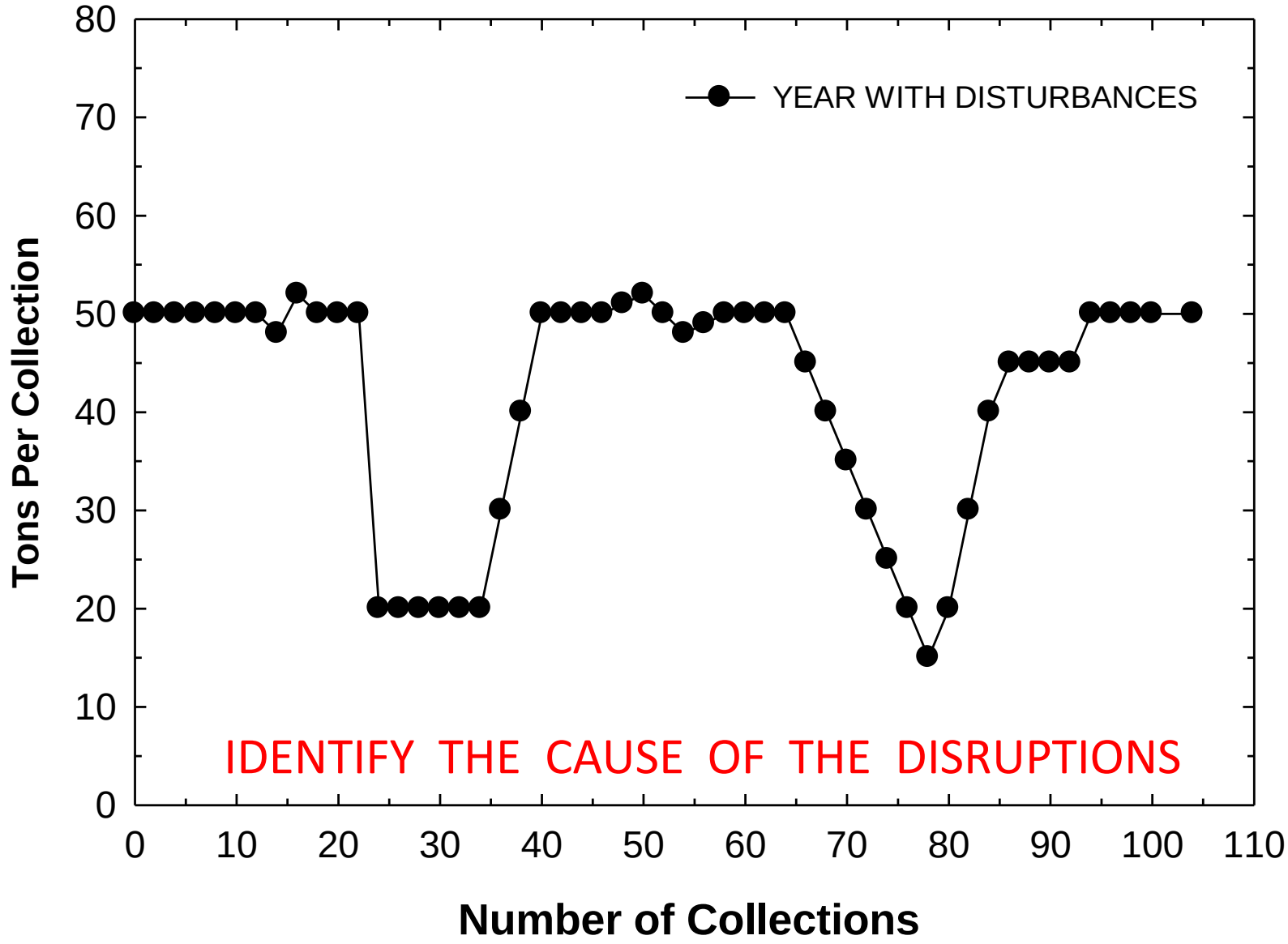

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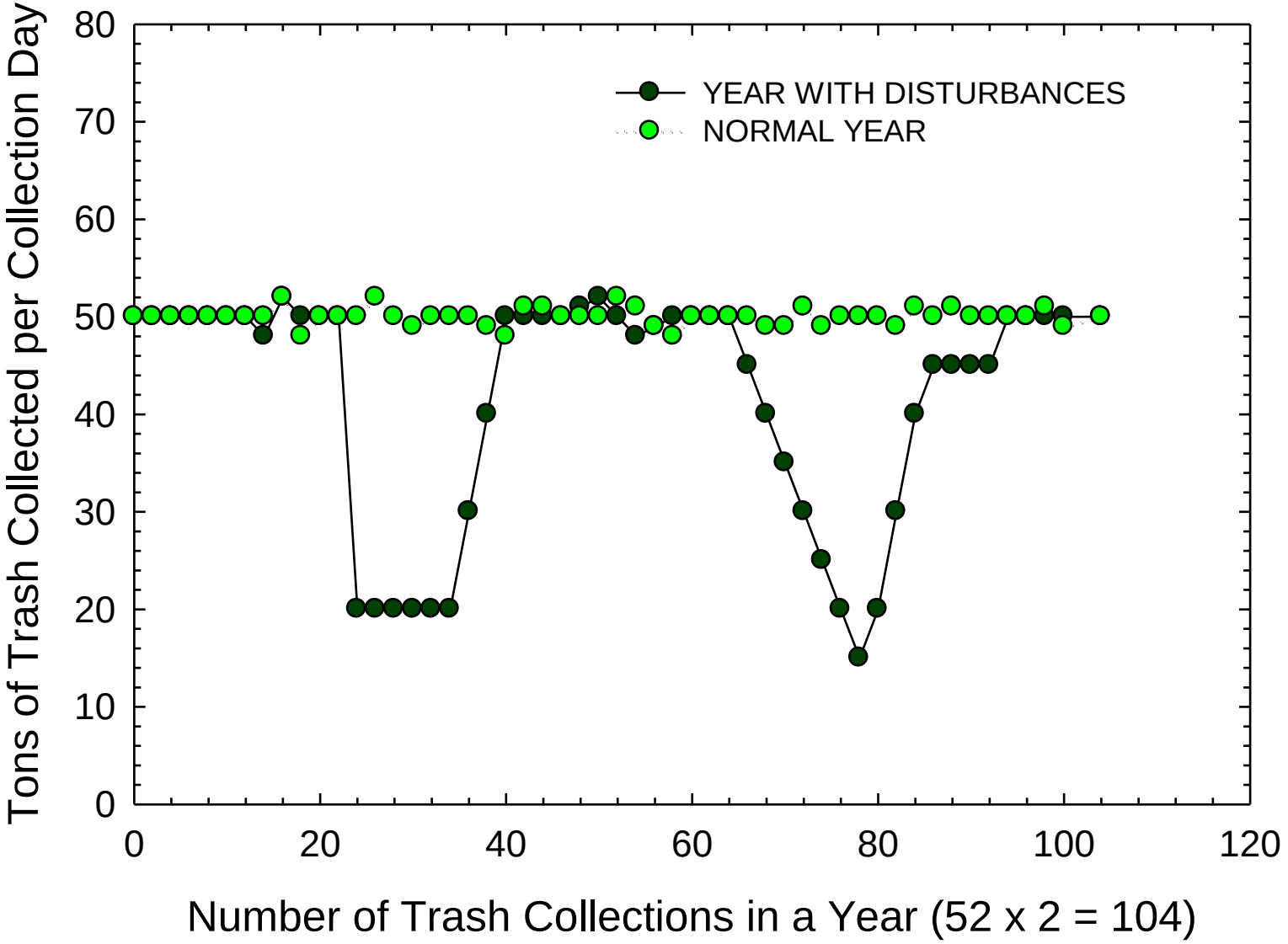
Analysis of Data Collected During CCSSMSW

Hypothetical Example of Implementation of the Utility Function



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INTERPRETATION OF THE UTILITY FUNCTION

- **Look for clear indications of service disruption. IDENTIFY THE CAUSE.**
- **They will manifest themselves as “reduction” of service and will appear as “dips” that eventually recover to the 100% service condition.**
- **Quantify the area between the line representing 100% service and that representing reduced/disrupted service (integrate the reduced service line).**
- **This quantity typically is a fraction of the full service given during the year.**
- **Consider that in our example the disruption resulted in 9% reduction of service for the year as measured by the fewer than expected tons collected.**
- **Make operational modifications to improve performance in subsequent years.**
- **Develop the utility function for a subsequent year by intense record keeping and compare to utility plot of prior year.**

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Hypothetical Example of Implementation of the Utility Function Analysis of Data Collected During CCSSMSW

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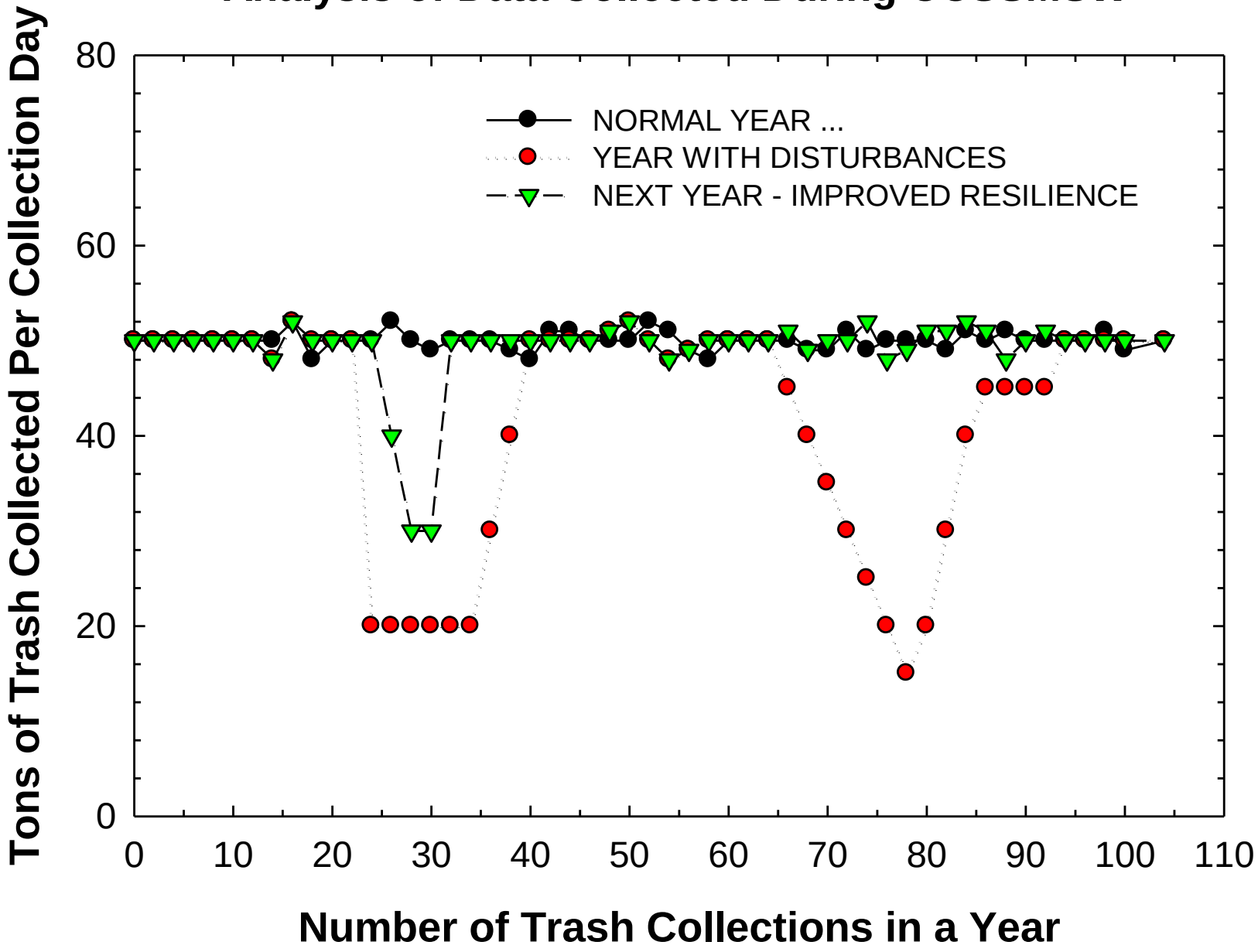

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WHAT CAN WE LEARN FROM THE SHAPE OF THE UTILITY FUNCTION

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- **Sharp and sudden drop in capacity to provide service:**
  ex: earthquake, landslide, collapse of bridge or overpass.

- **Slow and gradual drop in capacity to provide service:**
  ex: flooding of river bed, continuous rainfall and local flooding, heavy and prolonged snow storm .

- **Sharp and sudden recovery in capacity to provide service:**
  ex: opening bridges or roads back to traffic, fixing mechanical or electrical malfunctioning equipment.

- **Slow recovery in capacity to provide service:**
  ex: subsiding flood waters back into the river bed. Removal of snow.

FACTORS AFFECTING THE UTILITY FUNCTION

The plot constitutes the baseline for the resilience analysis that will commence in the immediately following year and beyond

It is often suggested that SEVERAL utility functions be developed using different indices for the same operational component to test for suitability

Alternative Indices:
number of collection trucks on route
number of staff on the road
etc.

Some indices may be easier to quantify than others over the years making them more convenient to use and perhaps easier to interpret

EFFECT OF OPERATIONAL IMPROVEMENTS ON CCSSMSW RESILIENCE

Recall the definition of the term:

Resilience is a measure of how quickly the system recover to full capacity.

If last year's disruption resulted in 9% loss of productivity, we will be expected to make changes in how we collect refuse in critical circumstances with the hope of improvement next year.

Repeating the same observations in the subsequent year we observe that the total disruption resulted in 6% loss of productivity

The conclusion is that:

The resilience of CCSSMSW operations improved by 3%.

Note: in making this statement we are assuming that the type of disruption, their intensities and their durations during the two years are similar.

RESILIENCE ANALYSIS FOR THE ENTIRE AGENCY

- In the hypothetical example the resilience of CCSSMSW improved by 3%.

- Consider that in the same time period, similar analyses
  for the other five operating components of the agency,
  the resilience improved by 2, 3, 1, 4, and 5 percent respectively.

- Also consider that the annual expenditure fractions are:
  a = 35% ; b = 20 %; c = 15%; d = 13% ; e = 10 ; f = 7 (a +….+ f =100)

- Then the improvement in the resilience of the entire agency will be:

RES = 0.35x3% + 0.20x2% + 0.15x3% + 0.13x1% + 0.10x4% +0.07x5%) = 2.78

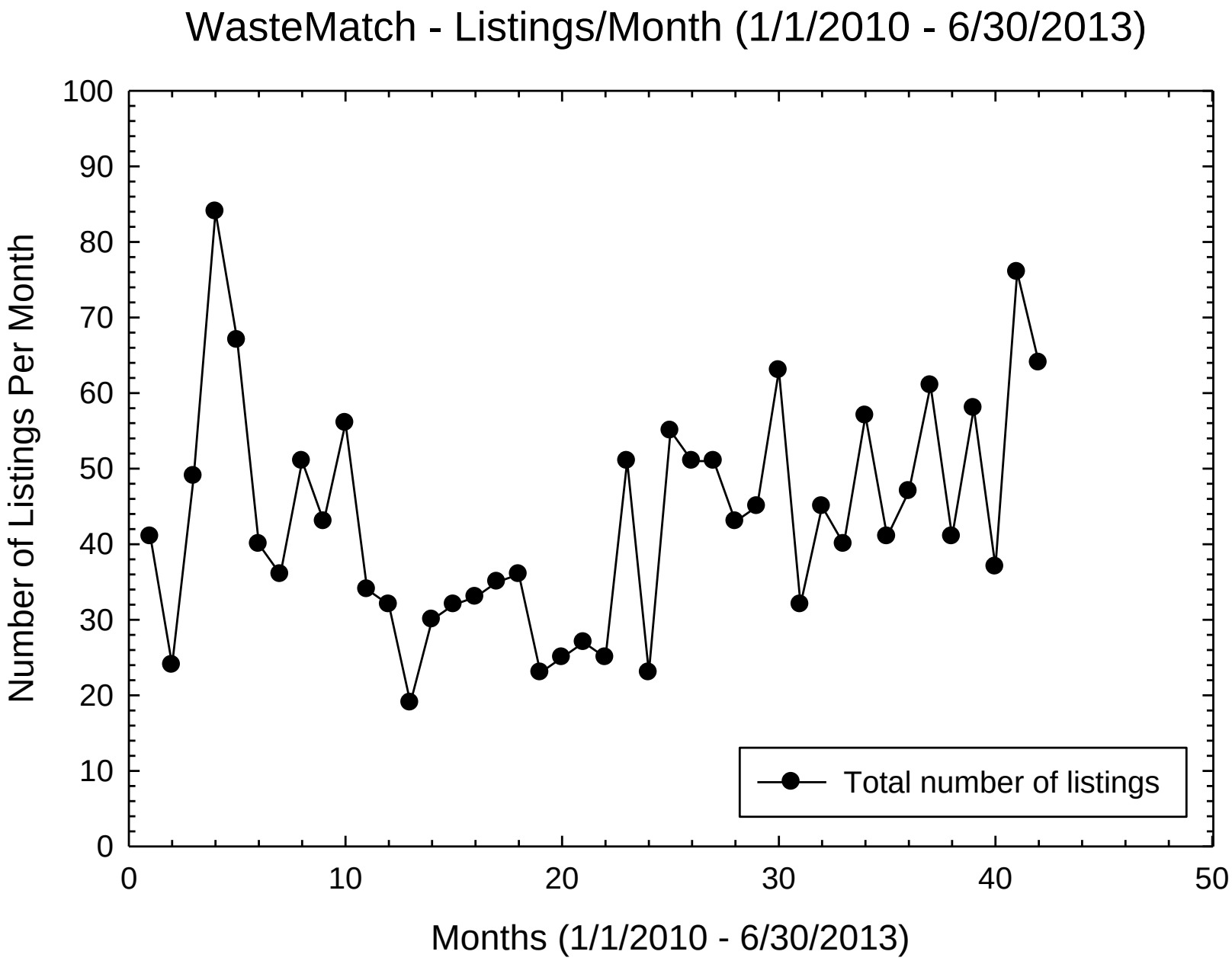
CONCLUSION = AGENCY RESILIENCE IMPROVED BY 2.78%

REUSENYC

ORGANIZATIONS INVOLVED IN MATERIALS REUSE

Goodwill Industries
Build It Green
Materials for the Arts
WasteMatch
Room to Grow
Other….

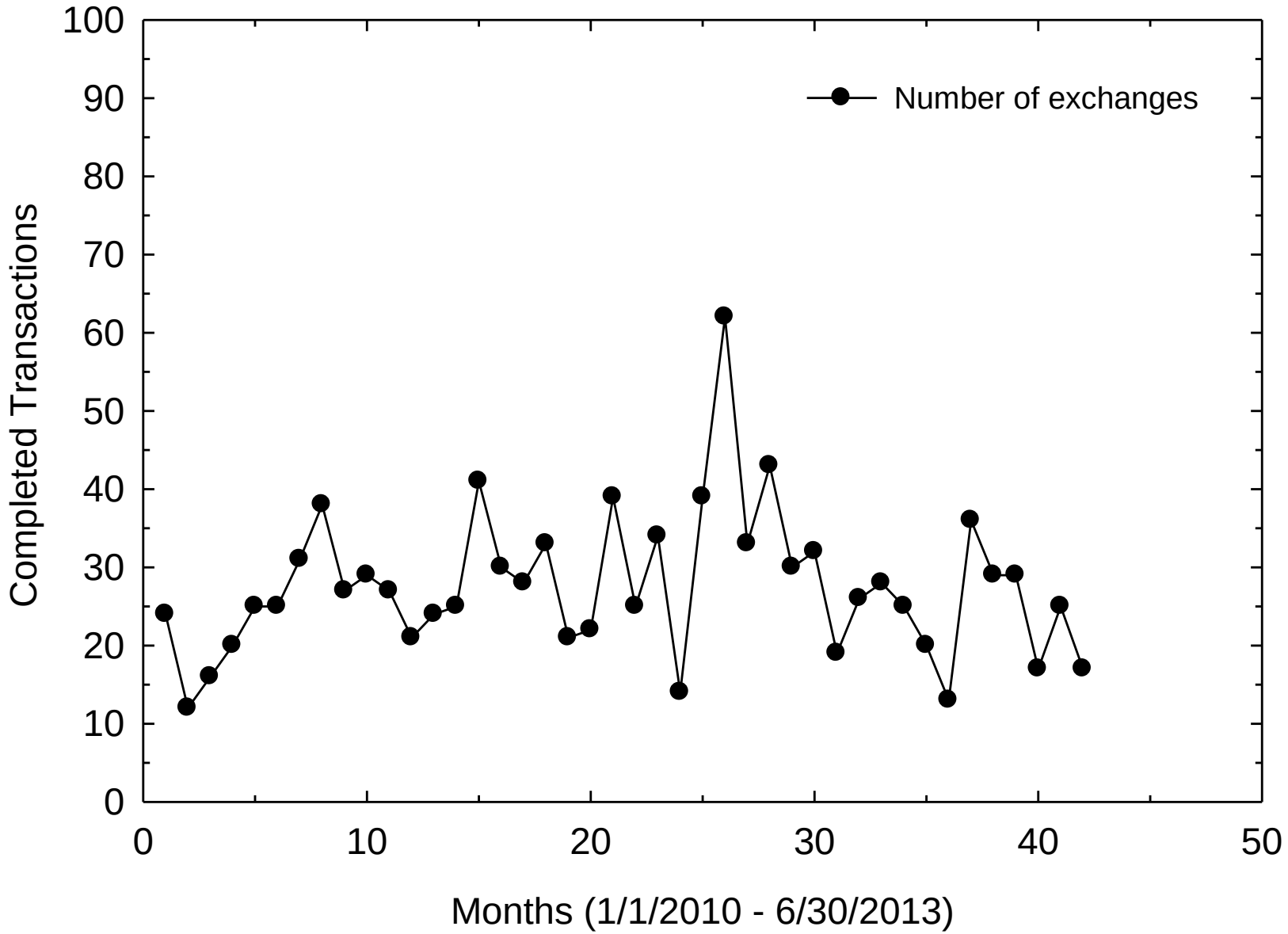
EXAMPLES OF UTILITY FUNCTIONS



EXAMPLES OF UTILITY FUNCTIONS

WasteMatch

Completed Transactions (1/1/2010 - 6/30/2013)



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EXAMPLES OF UTILITY FUNCTIONS
Build It Green - New York City

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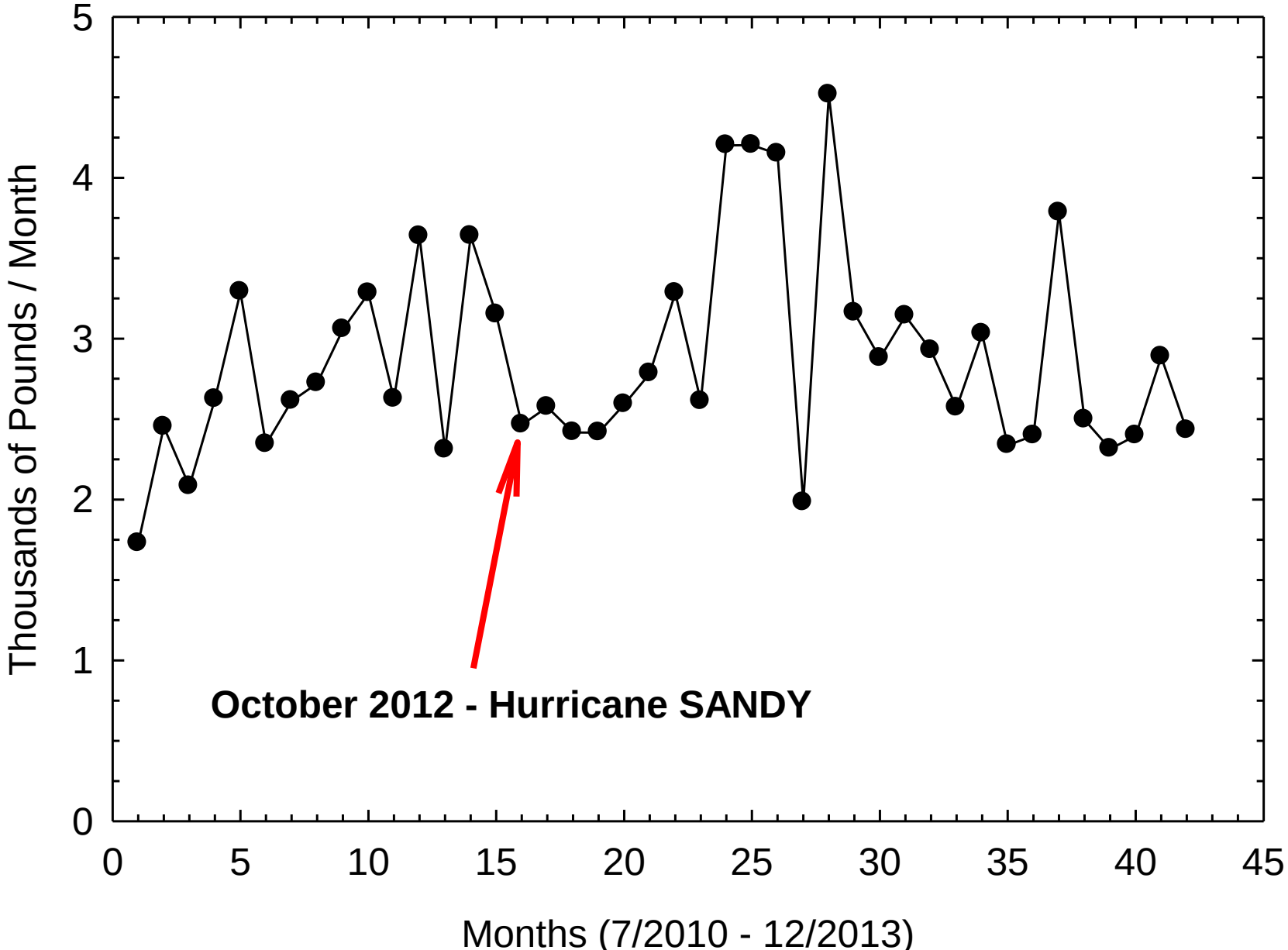

Common to Materials Reuse Organizations

- Seasonal variation in output.
- Lack of consistent data collection.
- The impact of only large disruptions can be detected.
- Small operations present highly variable diversion rates
- Reliable utility functions difficult to develop.
- Market share currently very small. They must be promoted.

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is the plan for a strong and just city. Together with all New Yorkers, we're acting on our plan for growth, sustainability, resiliency, and equity. Will you be a part of it?

NYC Mayor Bill DeBlasio

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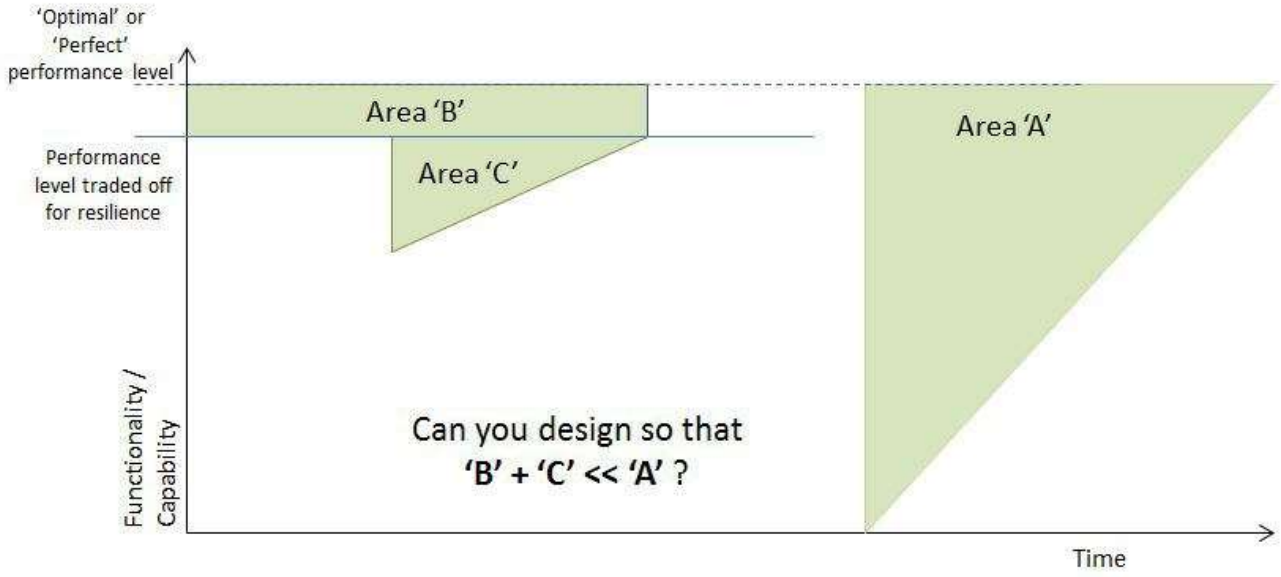
So the key question becomes the relative sizes of the shaded areas. Can you design the 'resilient' system on the left so the enduring cost is small and the cost of failure is much reduced, bearing in mind the probability of failure.



This still leaves the problem of **choosing** and then **quantifying** the 'functionality' or 'capability' dimension, and little detail of the probability of failure. But now there's a clear basis for debate and for the dimensions of the topics of the debate.