Organizational decision making and household response to tsunami evacuation warnings

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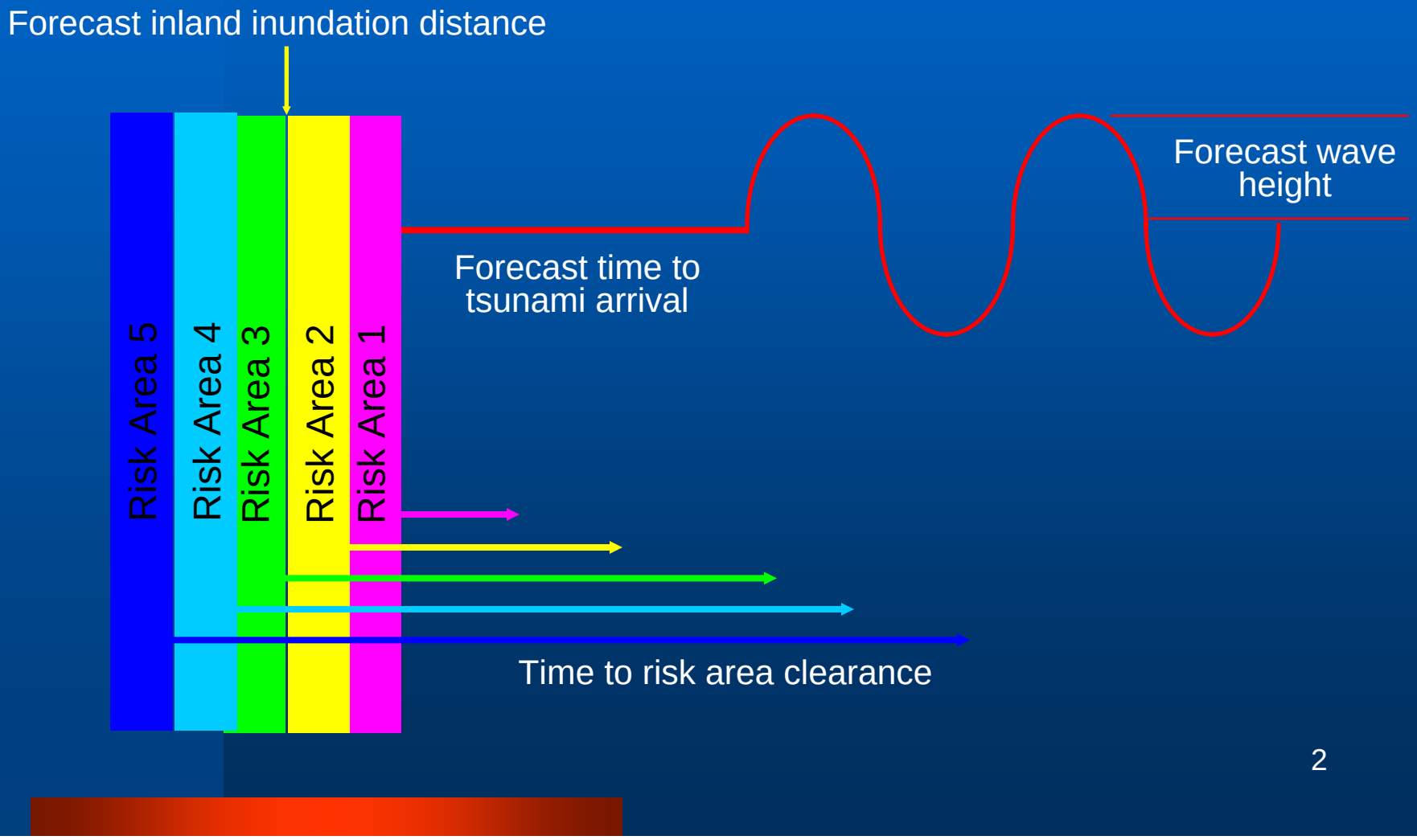
A Quantitative Model of Evacuation Behavior

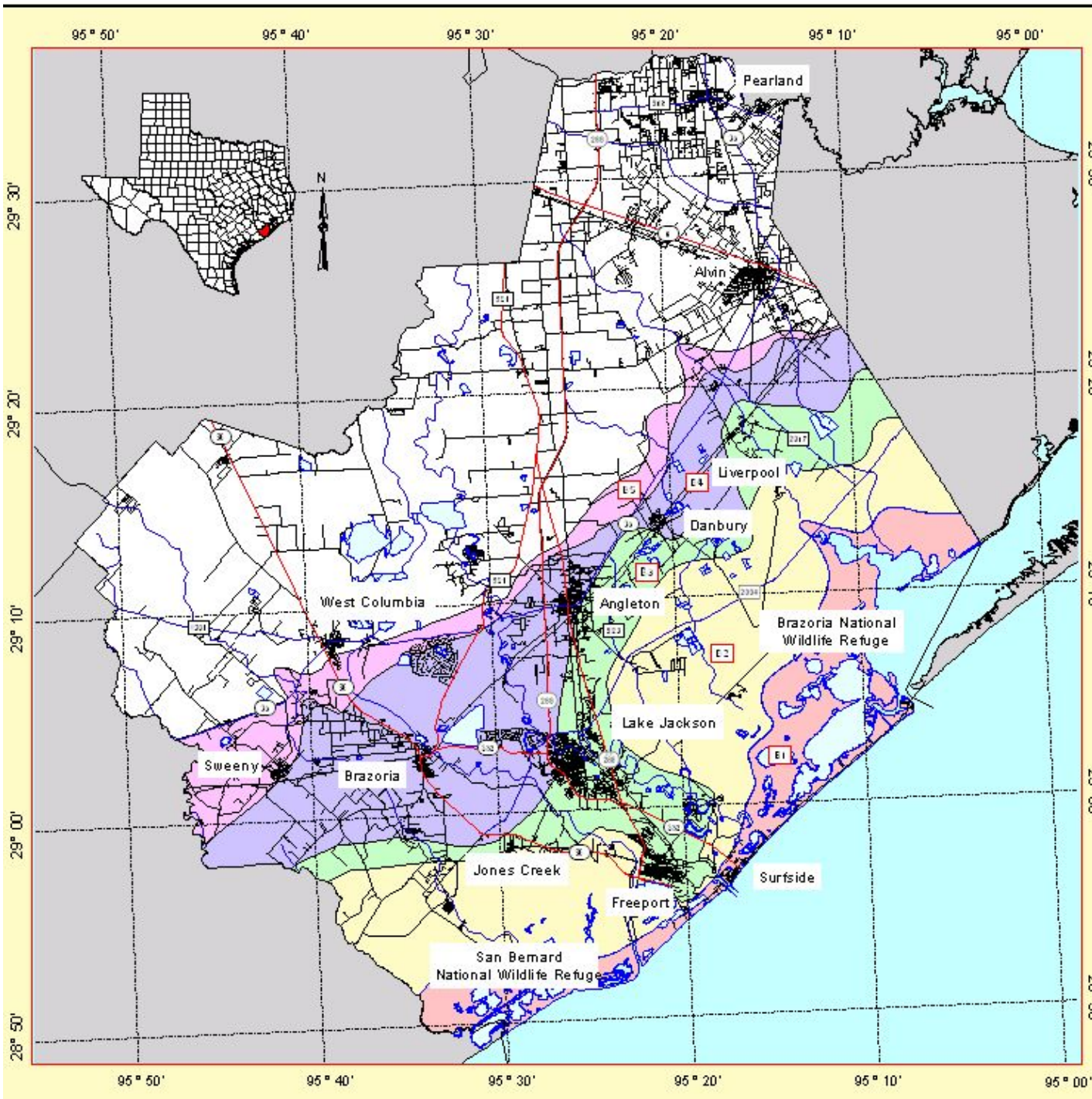


A Quantitative Model of Evacuation Behavior

- Step 1: Identify inundation zones for different tsunami magnitudes.
- Step 2: Assess evacuation route system (ERS) capacity.
  - Define the ERS.
  - Examine ERS geometry to identify the principal evacuation routes and their collector routes.
  - Estimate individual route capacities.

A Quantitative Model of Evacuation Behavior

- Step 3: Assess evacuation demand.
  - Calculate the number of households in each risk area and the number of evacuating vehicles per household.
  - Estimate the levels of warning compliance and spontaneous evacuation, by risk area.
  - Estimate trip generation times (TGTs).



Brazoria County

5 0 5 10 Miles

Saffir-Simpson Scale		Legend
Hurricane Category	Windspeed (MPH)	Primary Evacuation Route
		Secondary Evacuation Route
		County Boundary
1	74-95	Risk Area 1
2	96-110	Risk Area 2
3	111-130	Risk Area 3
4	131-155	Risk Area 4
5	> 155	Risk Area 5

Risk Area numbers correspond to hurricane categories. For example, in the event of a Category 3 hurricane, Risk Areas 1, 2, 3 would be threatened.

What To Do When A Hurricane Threatens

First, review the evacuation tips on the reverse side. Next, locate the hurricane risk area in which you live. If you are near the boundary of two risk areas, assume you are in the one nearest the coast. Now, find the evacuation route nearest your home and the connecting routes to get you there.

If you live on a barrier island, on the coast, in a mobile home near the coast, or in a low-lying or flood-prone area near the coast, plan to evacuate any time a storm threatens.

Otherwise, get ready to go, and as soon as local officials recommend evacuation for your community, leave immediately.

The table below provides an estimate of the time it will take to get all people evacuating from affected risk areas beyond the risk area boundary in specific categories of storms. Most people will require additional travel time to get to their final destination.

Estimated Time to Evacuate All Areas at Risk

Hurricane Category	Risk Areas Affected	Estimated Evacuation Time (in hours)
1	B1	7
2	B1, B2	9
3	B1, B2, B3	13
4	B1, B2, B3, B4	15
5	B1, B2, B3, B4, B5	15

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Estimated Warning Compliance and Spontaneous Evacuation

Table 1: Smoothed percentages of households expecting to evacuate for hurricanes in Category One through Category Five, by Risk Area.

Risk Area	Category One	Category Two	Category Three	Category Four	Category Five
1	45.9	63.7	87.8	98.2	100.0
2	35.9	53.7	77.8	88.2	91.4
3	31.1	48.9	73.0	83.4	86.6
4	28.2	46.0	70.1	80.5	83.7
5	26.5	44.3	68.4	78.8	82.0

Estimated Trip Generation Times

- The evacuation time estimate (ETE) for a *single* household to evacuate is the sum of the time to
  1. Receive a warning,
  2. Prepare to evacuate,
  3. Travel on collectors to the primary evacuation route,
  4. Wait for access to the primary evacuation route, and
  5. Travel on the primary evacuation route.
- The time needed for *all* households to enter the ERS is defined by distributions of ETE components 1 and 2, which yield the trip generation time (TGT) distribution.

Estimated Trip Generation Times

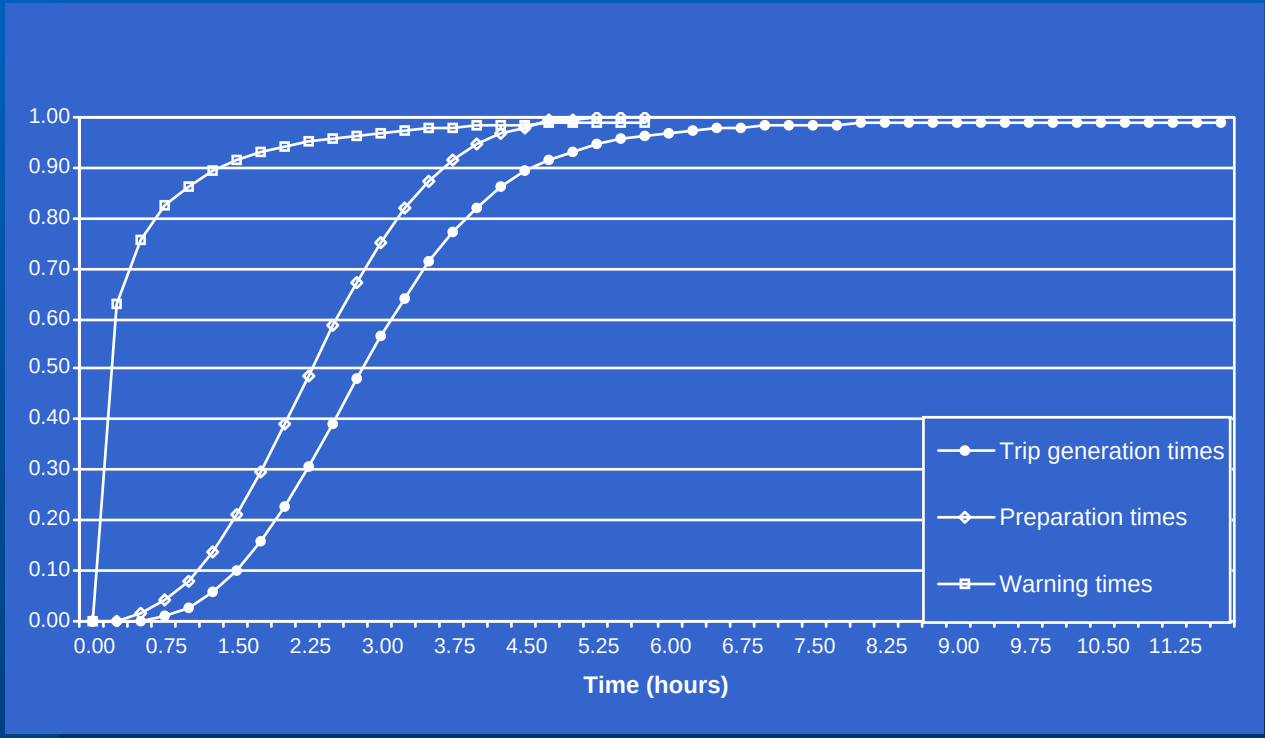

Figure 1: Synthesized household TGT distribution

Determinants of Trip Generation Times

- Warning reception time is a function of:
  - Source, channel, message, receiver, and feedback factors
- Evacuation preparation time has two components
  - Psychological preparation, and
  - Logistical preparation.
- Both of these are affected by
  - Pre-impact community and household preparedness,
  - Warning message content, and
  - Situational conditions.

Estimates of Evacuation Response Times

- Travel time from home via collector routes to the primary evacuation route (ETE component 3) is a function of the:
  - Distance from the home to the primary evacuation route, and
  - Average travel speed, which typically is about 30 mph (Witzig & Shilleen, 1987).

Estimates of Evacuation Response Times

- The time required for evacuating vehicles to wait for access to the primary evacuation route (ETE component 4) can be computed by means of four recursive equations.
- (1) $\Delta D_t = \Delta A_t + Q_{t-1}$, where
  - ΔD_t is the incremental traffic demand at time *t*,
  - ΔA_t is the incremental flow on arterial/collector routes at time *t,* and
  - Q_t is the size of the queue awaiting access to the primary evacuation route at time *t* (Q_0 is assumed to be zero).

Estimates of Evacuation Response Times

- (2) P_t = Min (ΔD_t, C), where
  - P_t is the primary evacuation route's traffic flow at time *t,* and
  - C is evacuation route capacity (which is often assumed to be 80% of normal capacity).
- (3) $E_t = P_t + E_{t-1}$, where
  - E_t is the total number of vehicles that have entered the evacuation route system through time *t*.
- (4) $Q_t = \Delta D_t - C$.

Estimates of Evacuation Response Times

- These four equations are solved repeatedly at successive time intervals $t \geq 1$ until
  - All transients have entered the primary evacuation route, and
  - All households attempting to evacuate (compliant evacuees + spontaneous evacuees) have entered the primary evacuation route.

Estimates of Evacuation Response Times

- Travel time on the primary evacuation route from the access point to the edge of the area at risk (ETE component 5) is a function of:
  - The distance from the access point to the edge of the area at risk, and
  - The average travel speed, which typically is about 30 mph (Witzig & Shilleen, 1987).

Estimates of Evacuation Response Times

- This procedure
  - Has been used to generate the evacuation time estimates (ETEs) currently used by the State of Texas for hurricane evacuations.
  - Is currently being implemented in MS-Access/Visual Basic to develop an evacuation management decision support system (EMDSS) for research and training.

References

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