



The EF-Scale As a Severe Weather Awareness Tool



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ORIGINAL FUJITA SCALE		ENHANCED FUJITA SCALE	
F5	261-318 mph	EF5	+200 mph
F4	207-260 mph	EF4	166-200 mph
F3	158-206 mph	EF3	136-165 mph
F2	113-157 mph	EF2	111-135 mph
F1	73-112 mph	EF1	86-110 mph
F0	<73 mph	EF0	65-85 mph



Objectives

- To compare the old Fujita Scale to the new Enhanced or EF-Scale
- To discuss the pros and cons of the EF-scale and its advantages over the old F-scale
- To introduce an alternative use of the EF-Scale as a public outreach and severe weather safety awareness tool

SCALE	WIND ESTIMATE *** (MPH)	TYPICAL DAMAGE
F0	< 73	Light damage. Some damage to chimneys; branches broken off trees; shallow-rooted trees pushed over; sign boards damaged.
F1	73-112	Moderate damage. Peels surface off roofs; mobile homes pushed off foundations or overturned; moving autos blown off roads.
F2	113-157	Considerable damage. Roofs torn off frame houses; mobile homes demolished; boxcars overturned; large trees snapped or uprooted; light-object missiles generated; cars lifted off ground.
F3	158-206	Severe damage. Roofs and some walls torn off well-constructed houses; trains overturned; most trees in forest uprooted; heavy cars lifted off the ground and thrown.
F4	207-260	Devastating damage. Well-constructed houses leveled; structures with weak foundations blown away some distance; cars thrown and large missiles generated.
F5	261-318	Incredible damage. Strong frame houses leveled off foundations and swept away; automobile-sized missiles fly through the air in excess of 100 meters; trees debarked; incredible phenomena will occur.

Figure 1. The old Fujita Scale.

Fujita Scale Damage Indicators

Photo courtesy NWS Birmingham



Figure 3. F0 tornado damage caused by winds less than 73 mph according to the old Fujita Scale.



Figure 4. F1 tornado damage caused by winds of 73-112 mph according to the old Fujita Scale.

Photo courtesy NWS Memphis



Figure 5. F2 tornado damage caused by winds of 113-157 mph according to the old Fujita Scale.

Shortcomings of the Fujita Scale

- No way to accurately assess tornado damage to industrial buildings
- Did not account for design or structural integrity of buildings
- Did not address scouring of road surfaces or situations where tornado moved across open crop or grass lands
- Difficult to apply with no damage indicators
- Based on worst damage observed along entire tornado track
- Overestimated wind speeds greater than F3
- Oversimplification of the damage description

Enhanced Fujita Scale Damage Indicators

ENHANCED FUJITA SCALE

EF0 (Gale) 65-85 mph | 3-second gusts

EF1 (Weak) 86-110 mph | 3-second gusts

EF2 (Strong) 111-135 mph | 3-second gusts

EF3 (Severe) 136-165 mph | 3-second gusts

EF4 (Devastating) 166-200 mph | 3-second gusts

EF5 (Incredible) over 200 mph | 3-second gusts

Figure 2. The Enhanced Fujita Scale.

NUMBER	DAMAGE INDICATOR	ABBREVIATION
1	Small barns, farm outbuildings	SBO
2	One- or two-family residences	FR12
3	Single-wide mobile home (MHSW)	MHSW
4	Double-wide mobile home	MHDW
5	Apt, condo, townhouse (3 stories or less)	ACT
6	Motel	M
7	Masonry apt. or motel	MAM
8	Small retail bldg. (fast food)	SRB
9	Small professional (doctor office, branch bank)	SPB
10	Strip mall	SM
11	Large shopping mall	LSM
12	Large, isolated ("big box") retail bldg.	LIRB
13	Automobile showroom	ASR
14	Automotive service building	ASB
15	School - 1-story elementary (interior or exterior halls)	ES
16	School - jr. or sr. high school	JHSH
17	Low-rise (1-4 story) bldg.	LRB
18	Mid-rise (5-20 story) bldg.	MRB
19	High-rise (over 20 stories)	HRB
20	Institutional bldg. (hospital, govt. or university)	IB
21	Metal building system	MBS
22	Service station canopy	SSC
23	Warehouse (tilt-up walls or heavy timber)	WHB
24	Transmission line tower	TLT
25	Free-standing tower	FST
26	Free standing pole (light, flag, luminary)	FSP
27	Tree - hardwood	TH
28	Tree - softwood	TS

Figure 6. The 28 EF-Scale damage indicators.

Degrees of Damage for One and Two Family Residences

2. ONE-AND-TWO-FAMILY RESIDENCES (FR12) (1000-5000 square feet)
 Typical Construction
- Asphalt shingles, tile, slate, or metal roof covering
 - Flat, gable, hip, mansard, or mono-sloped roof or combinations thereof
 - Plywood/OSB or wood plank roof deck
 - Prefabricated wood trusses or wood joist and rafter construction
 - Brick veneer, wood panels, stucco, EIFS, vinyl, or metal siding
 - Wood or metal stud walls, concrete blocks or insulating-concrete panels
 - Attached single or double garage

DOD *	Damage description	EXP	LB	UB
1	Threshold of visible damage	65	53	80
2	Loss of roof covering material (<20%), gutters and/or awning; loss of vinyl or metal siding	79	63	97
3	Broken glass in doors or windows	96	79	114
4	Uplift of roof deck and loss of significant roof covering material (>20%); collapse of chimney; garage doors collapse inward; failure of porch or carport	97	81	116
5	Entire house shifts off foundation	121	103	141
6	Large sections of roof structure removed; most walls remain standing	122	104	142
7	Top floor exterior walls collapsed	132	113	153
8	Most interior walls of top story collapsed	148	128	173
9	Most walls collapsed in bottom floor, except small interior rooms	152	127	178
10	Total destruction of entire building	170	142	198

Figure 7. Red denotes DOD 4 and EF-1 damage on the new EF-Scale. Yellow denotes wind speed range for F-1 damage according to the old F-Scale.



Figure 8. EF-0 tornado damage. Loss of small amount of roofing material.



Figure 9. EF-1 tornado damage. Uplift of roof deck and loss of significant amount of roof covering material, garage door collapsed outward



DI: FR12; DOD: 6; 52-170b-023

Figure 10. EF-2 tornado damage. Large sections of roof removed, most walls remain standing.

Degrees of Damage (DOD) for Small Barns and Farm Outbuildings

1. SMALL BARNS AND FARM OUTBUILDINGS (SBO)

Typical Construction

- Less than 2500 sq ft
- Wood or metal post and beam construction
- Wood or metal roof trusses
- Wood or metal panel siding
- Metal or wood roof
- Large doors

DOD	Damage Description	EXP	LB	UB
1	Threshold of visible damage	62	53	78
2	Loss of wood or metal roof panels	74	61	91
3	Collapse of doors	83	68	102
4	Major loss of roof panels	90	78	110
5	Uplift or collapse of roof structure	93	77	114
6	Collapse of walls	97	81	119
7	Overturning or sliding of entire structure	99	83	118
8	Total destruction of building	112	94	131

Figure 11. Red denotes DOD 2 or EF-1 damage on the EF-Scale. Yellow denotes the wind speed range corresponding to F-1 damage on the old F-Scale.

More damage caused by a weak EF-1 tornado

- April 26, 2007 Fleming County, KY
- EF-1 tornado occurred near Sunset and Hillsboro
- 3 barns totally destroyed
- 70 ft tall concrete grain silo blown over
- Dozens of trees uprooted and snapped
- Max winds of 105 mph



Figure 12. EF-1 tornado damage Fleming County, KY, 4/26/07



Figure 13. EF-1 tornado damage Fleming County, KY, 4/26/07

Degrees of Damage (DOD) for Single Wide Manufactured Homes

3. MANUFACTURED HOMES - SINGLE WIDE (MHSW)

Typical Construction

- Steel undercarriage supported on concrete block piers
- Metal straps and ground anchors (Frame and/or over-the-top strap anchors)
- Asphalt shingles or one-piece metal roof covering
- Wood roof joists
- Metal, vinyl or wood siding
- Wood stud walls and partitions
- Better construction in post 1974 models in coastal areas

DOD	Damage Description	EXP	LB	UB
1	Threshold of visible damage	61	51	76
2	Loss of shingles or partial uplift of one-piece metal roof covering	74	61	92
3	Unit slides off block piers but remains upright	87	72	103
4	Complete uplift of roof; most walls remain standing	89	73	112
5	Unit rolls on its side or upside down; remains essentially intact	98	84	114
6	Destruction of roof and walls leaving floor and undercarriage in place	105	87	123
7	Unit rolls or vaults; roof and walls separate from floor and undercarriage	109	96	128
8	Undercarriage separates from unit; rolls, tumbles and is badly bent	118	101	136
9	Complete destruction of unit; debris blown away	127	110	148

Figure 14. Red denotes DOD 8 or EF-2 damage on the EF-Scale. Yellow denotes the wind speed range corresponding to F-2 damage on the old F-Scale.



Figure 15. EF-1 tornado damage. Unit rolled upside down and bent but essentially intact.



Figure 16. High end EF-1 tornado damage. Destruction of roof and walls with floor and undercarriage left in place.

Only large, violent tornadoes can cause devastating damage. FALSE!



Figure 17. EF-2 tornado damage Wayne County, KY, 4/11/08

- EF-2 tornado damage from April 11, 2008
- Path length of 7 miles, max path width 400 yards (approx. 1200 feet)
- Occurred near Monticello, KY in Wayne County
- Peak winds estimated at near 130 mph (equivalent to category 3 hurricane)
- Trailer completely destroyed with debris scattered in multiple directions
- Destructive tornadoes CAN and DO happen outside of the Great Plains

Pros and Cons of the EF-Scale

Pros

- Uses 28 damage indicators
- Each damage indicator broken down into 3 to 10 degrees of damage
- Utilizes a total of over 200 degrees of damage to assess tornado intensity
- Enhanced description of damage with examples and photos of each level of damage
- Accounts for varying degrees of tree damage
- Damage assignment based on more than one structure along tornado track, if available
- Accounts for structural integrity of buildings and building design

Cons

- Does not include damage indicators that account for scouring of road surfaces
- Does not account for situations where tornado moves across crop land, open grasslands, or large open expanses of bare earth
- Does not account for changing building construction codes
- Performs poorly when evaluating tree damage

The EF-Scale as an Outreach and Severe Weather Awareness Tool

- Use EF-Scale to demonstrate how much lower wind speeds can cause larger amounts of damage than was previously thought
- Show the public visual evidence of the amount of destruction caused by weak EF-0 and EF-1 tornadoes
- Increase public awareness of the enhanced danger they are exposed to during severe weather
- Use JKL/LMK website, spotter/school talks, outreach activities, etc as mediums through which to convey the information in bullet point 2 above

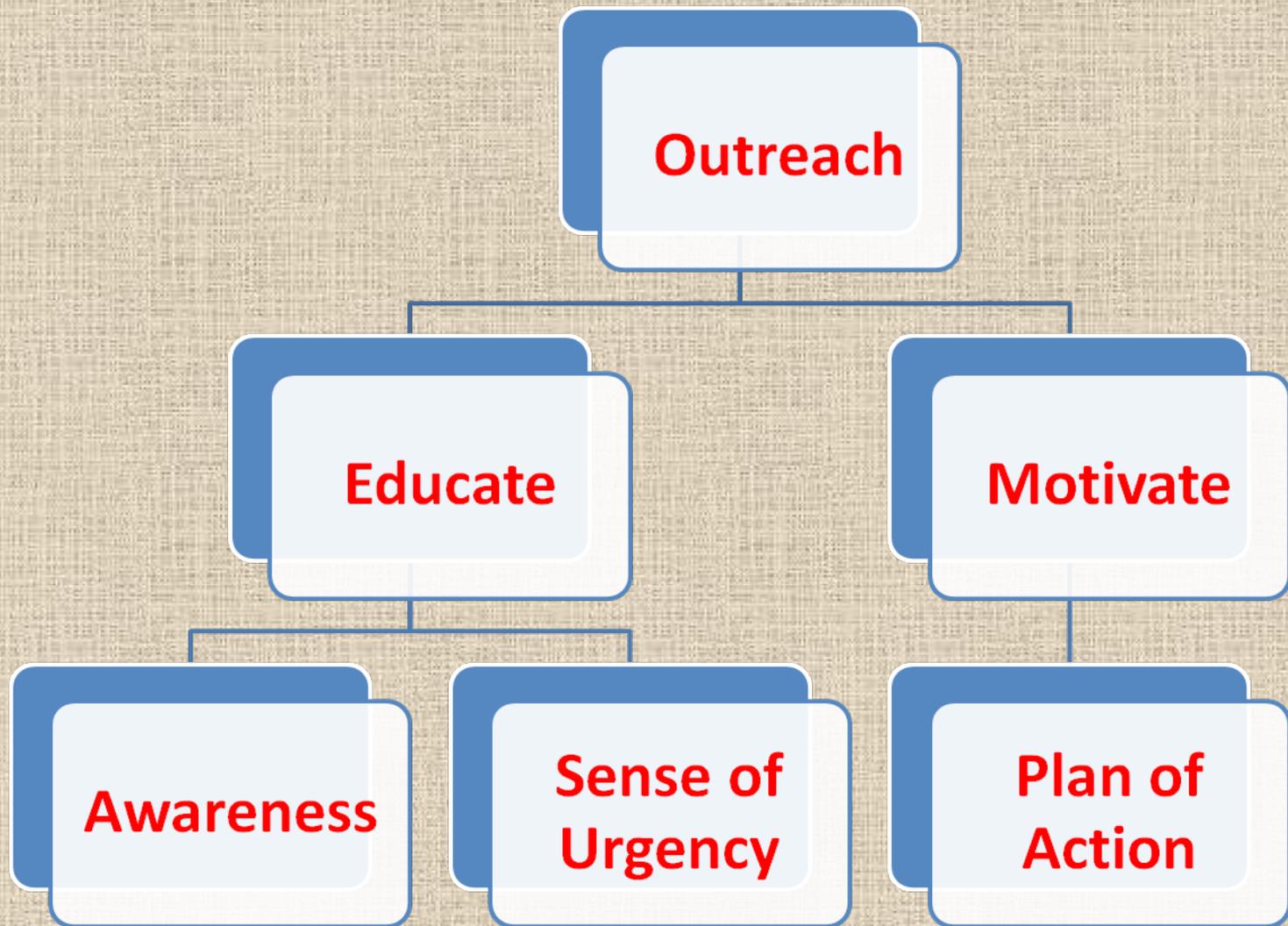


Figure 26. Flow chart outlining desired outcome of using EF-Scale as outreach tool.

An Interesting Statistic

- **325205** housing units with **97306** of those being trailer homes or 30% of the total (2000 Census)

These are the folks most at risk!

Conclusions

- EF-Scale provides much greater detail than old F-Scale when evaluating tornado intensity
- EF-Scale visual demonstrates over 200 ways in which tornadoes can cause damage to a home, business, or school
- Impoverished areas such as Eastern Kentucky are more vulnerable to severe weather
- Even weak tornadoes can cause large amounts of damage
- Public needs to be made more aware of the dangers of low end severe weather events through outreach and education