Calibration of PMIS Pavement Performance Prediction Models

Conducted as part of TxDOT Project 0-6386

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Introductory Webinar — February 3, 2012

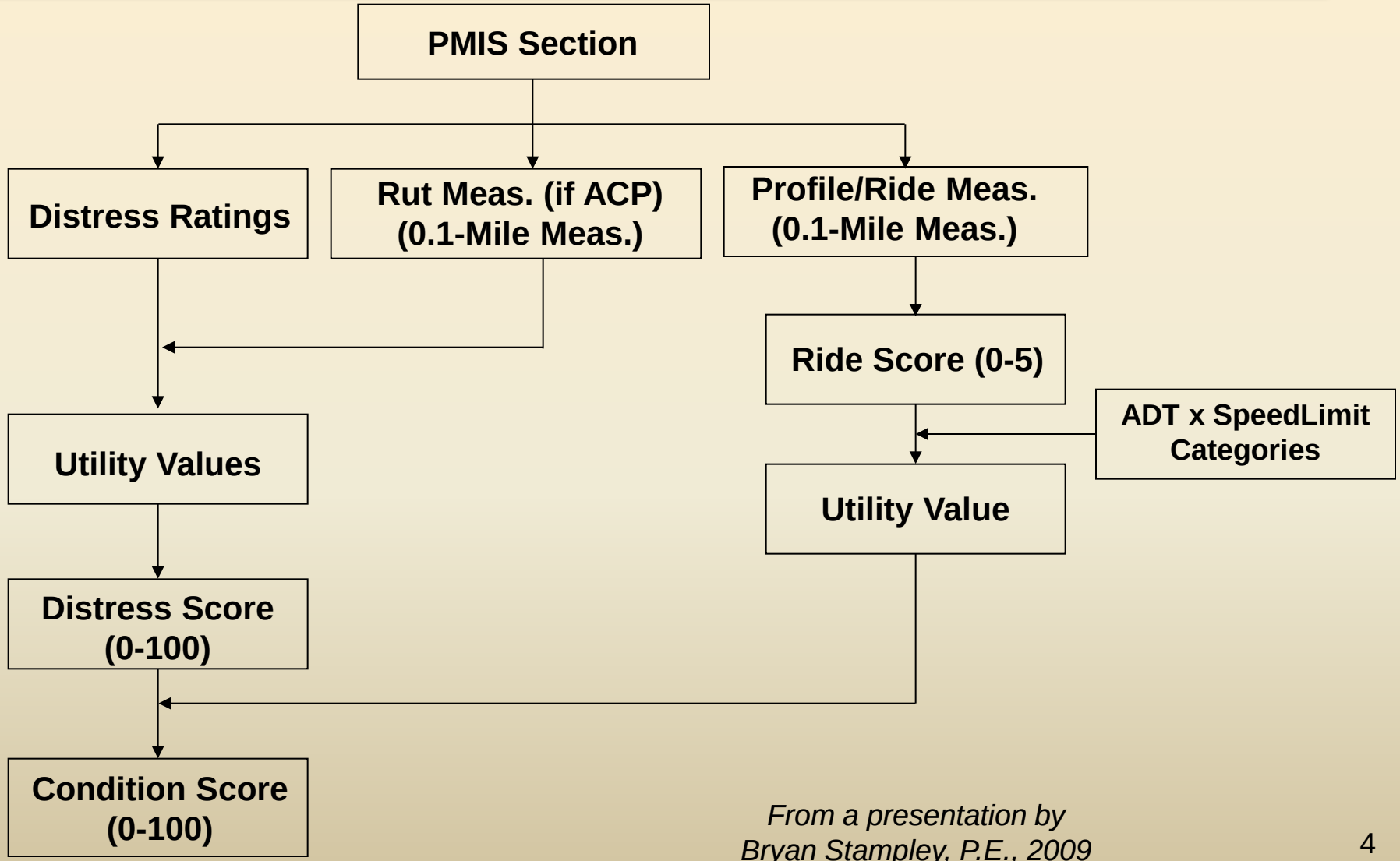
Objective of This Webinar

- Provide an Introduction (Overview) of the Process Used to Develop Improved PMIS Performance Prediction Models
- We Will Have a Web Survey to Go Over the Models Themselves, So You Can Suggest Improvements
- Please Note: These Models are for ACP (Flexible) Sections Only. PCC (Rigid) Models Will be Presented for Your Suggestions at a Later Date.

Model Calibration Objectives

- Improve the accuracy of PMIS pavement performance prediction models for Texas.
- Ensure logical performance superiority pattern across treatment types.

Pavement Condition Assessment in PMIS



From a presentation by Bryan Stampley, P.E., 2009

Distress Score and Condition Score Computations

Distress Utility

$$U_i = \begin{cases} 1.0 & when\ L_i = 0 \\ 1 - \alpha e^{-\left(\frac{\rho}{L_i}\right)^{\beta}} & when\ L_i > 0 \end{cases}$$

Distress density or quantity per section

Distress Score

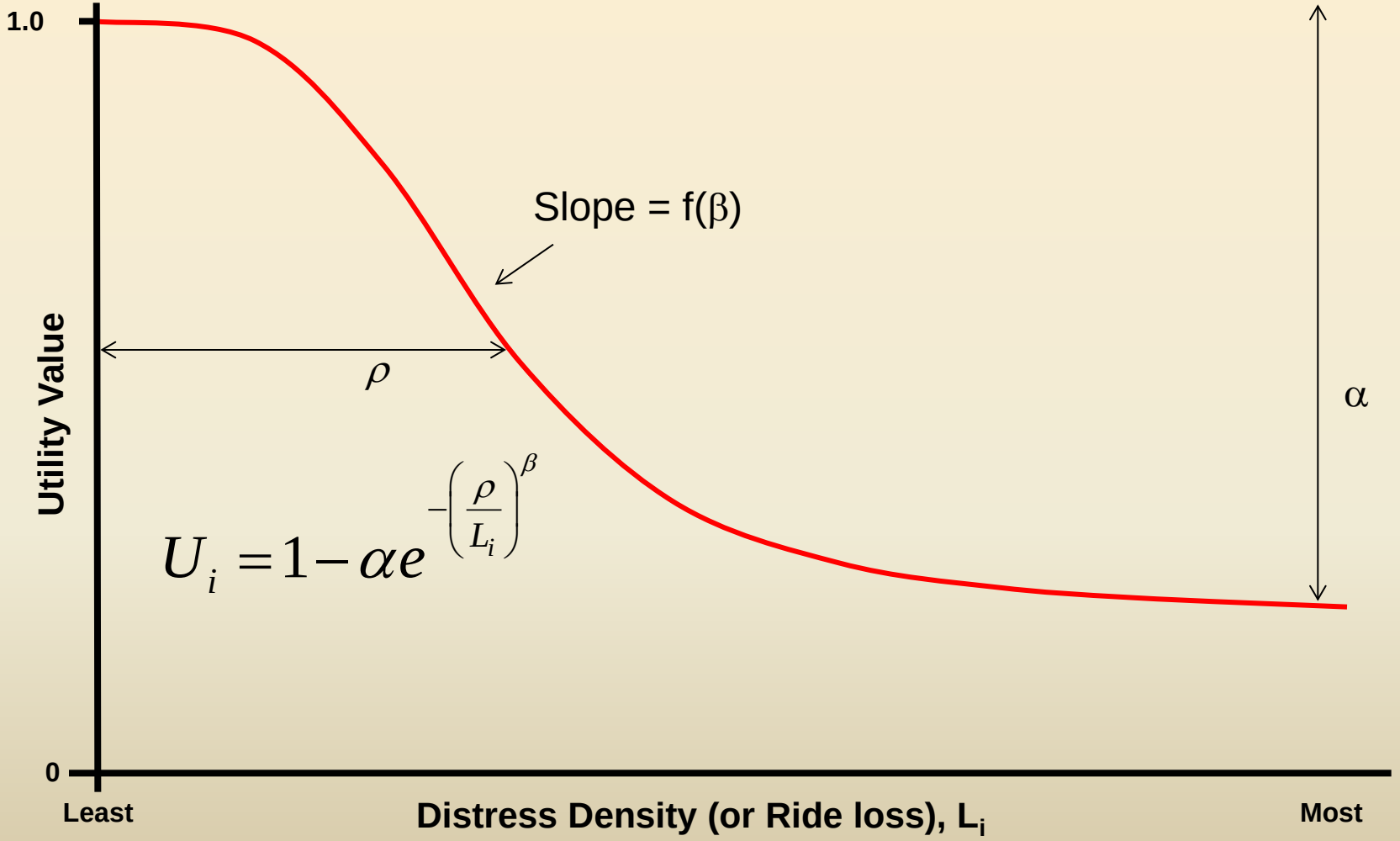
$$DS = 100 \times \prod_{i=1}^{n} U_i$$

n distress types considered in computing DS

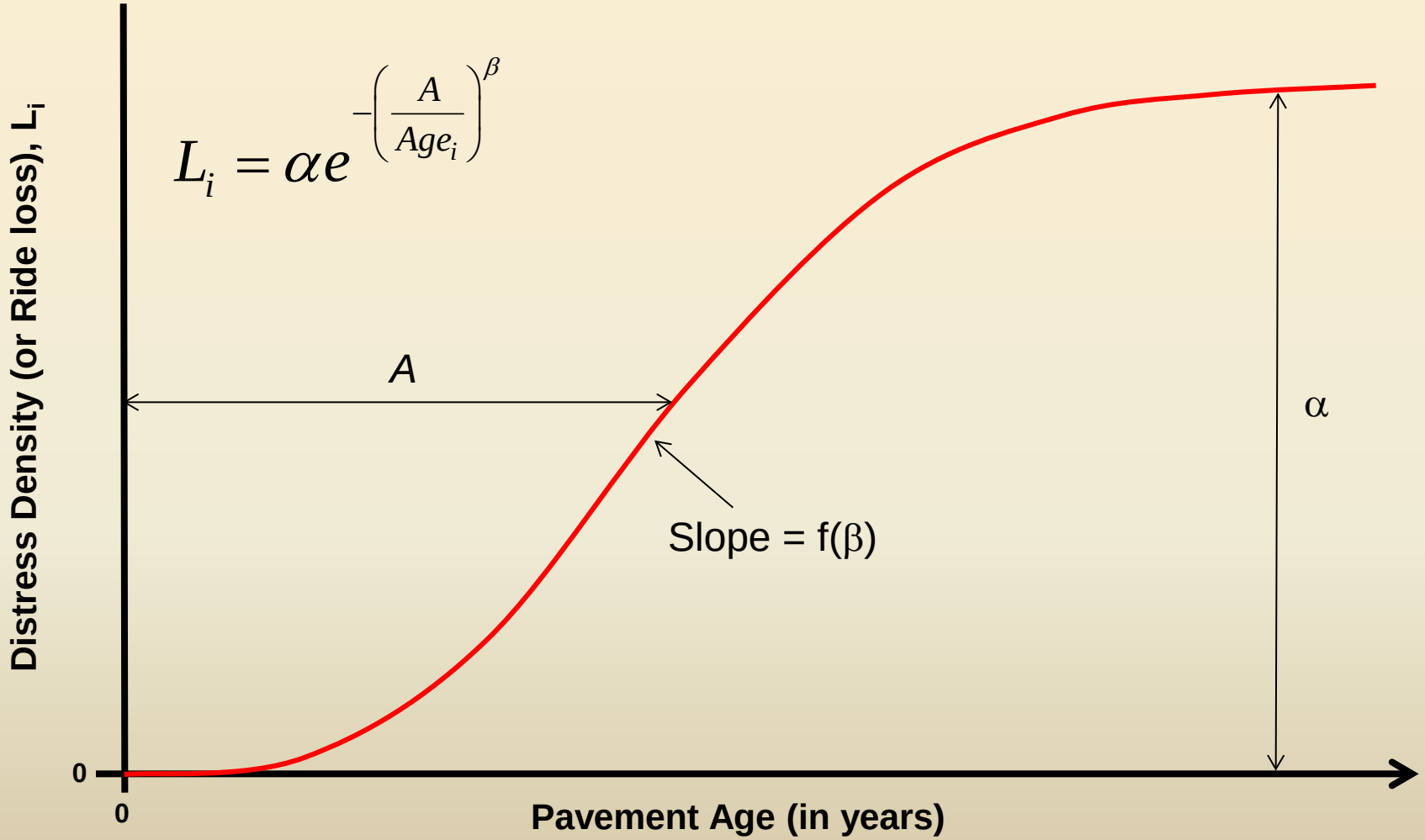
Condition Score

$$CS = U_{Ride} \times DS$$

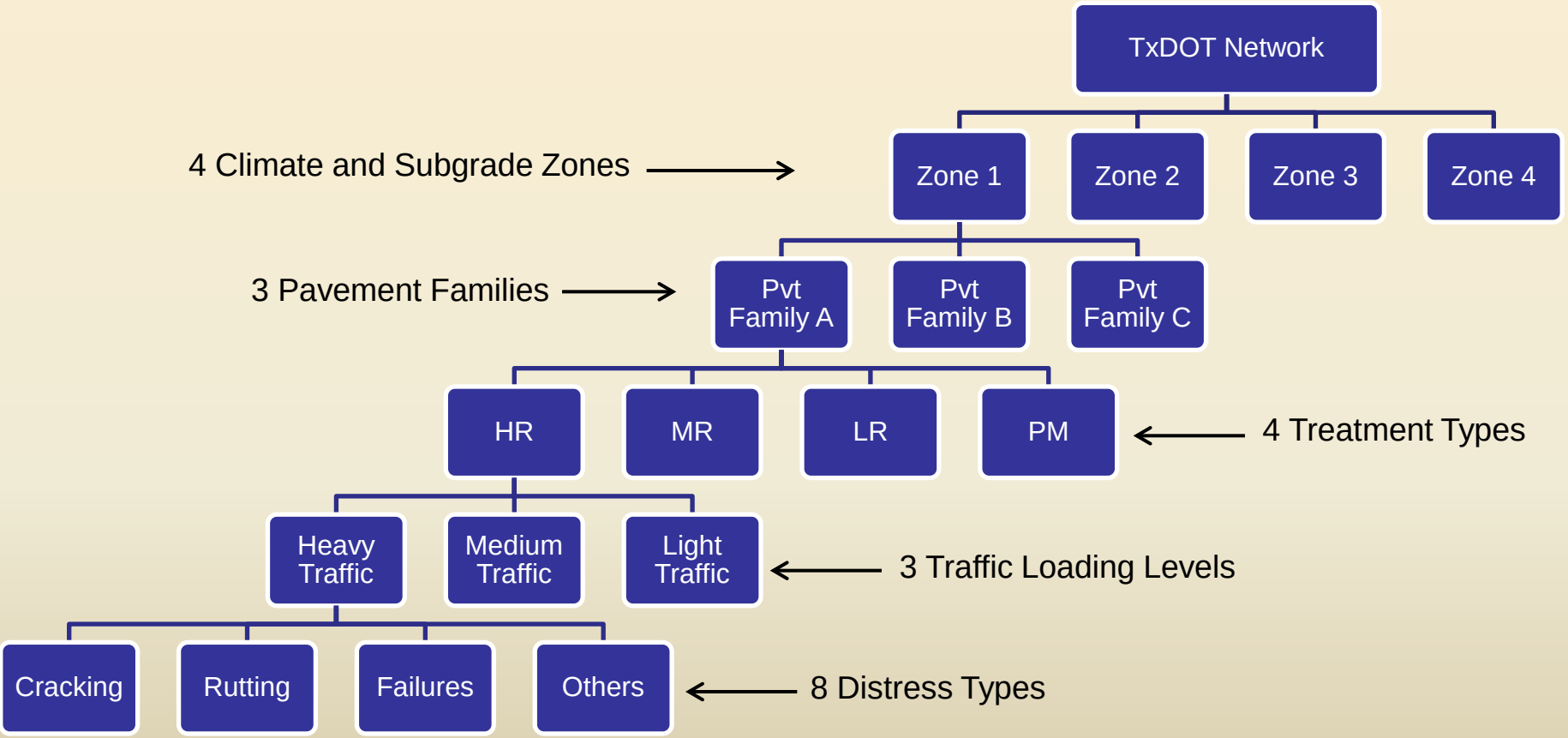
Utility Functions



Distress Prediction Models



Data Grouping — ACP Sections Only



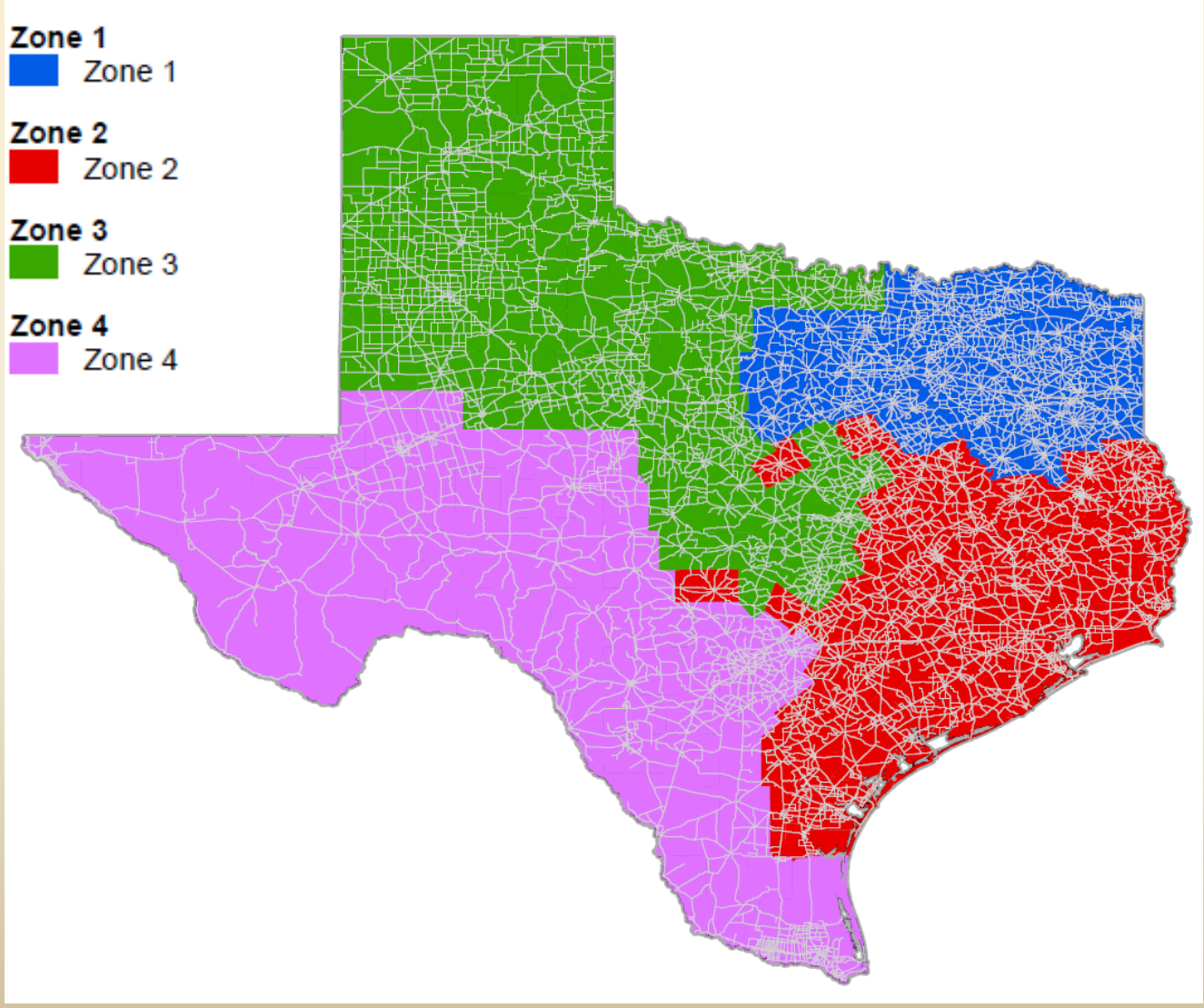
Climate and Subgrade Zones
(Based on PMIS Climate and Subgrade Data)

Zone 1:
wet-cold climate
poor, very poor,
or mixed subgrade.

Zone 2:
wet-warm climate
poor, very poor,
or mixed subgrade.

Zone 3:
dry-cold climate
good, very good,
or mixed subgrade.

Zone 4:
dry-warm climate
good, very good,
or mixed subgrade.



Pavement Families
(Based on PMIS Pavement Type)

Pavement Family A:
- Thick ACP (PMIS Pavement Type 4)
- Intermediate ACP (PMIS Pavement Type 5)
- Overlaid ACP (PMIS Pavement Type 9)

Pavement Family B:
- Composite pavement (PMIS Pavement Type 7)
- Concrete pavement overlaid with ACP (PMIS Pavement Type 8)

Pavement Family C:
- Thin ACP (PMIS Pavement Type 6)
- Thin-surfaced ACP (PMIS Pavement Type 10)

Typical Treatment Types in PMIS

Treatment Type	Thick ACP (Type 4)	Intermediate ACP (Type 5)	Thin ACP (Type 6)	Composite ACP over PCC (Type 7)	Concrete overlaid (Type 8)	Flexible overlaid (Type 9)	Thin-surfaced flexible base (Type 10)
PM	Crack seal, Surface seal	Crack seal, Surface seal	Crack seal, Surface seal	Crack seal, Surface seal	Crack seal, Surface seal	Crack seal, Surface seal	Surface seal, no patching
LR	Thin asphalt overlay	Thin asphalt overlay	Thin asphalt overlay	Thin asphalt overlay	Thin asphalt overlay	Thin asphalt overlay	Surface seal, Light/medium patching
MR	Thick asphalt overlay	Thick asphalt overlay	Mill and asphalt overlay	Mill and asphalt overlay	Mill and asphalt overlay	Thick asphalt overlay	Surface seal, Heavy patching
HR	Remove asphalt surface, Replace and rework base	Remove asphalt surface, Replace and rework base	Reconstruct	Remove asphalt surface, Replace and rework base	Remove asphalt surface, Replace and rework base	Remove asphalt surface, Replace and rework base	Rework base & surface seal

Traffic Levels
(Based on 20-Year Projected 18-kip ESAL)

Low Traffic: Less than 1 million.

Medium Traffic: 1 million to less than 10 million.

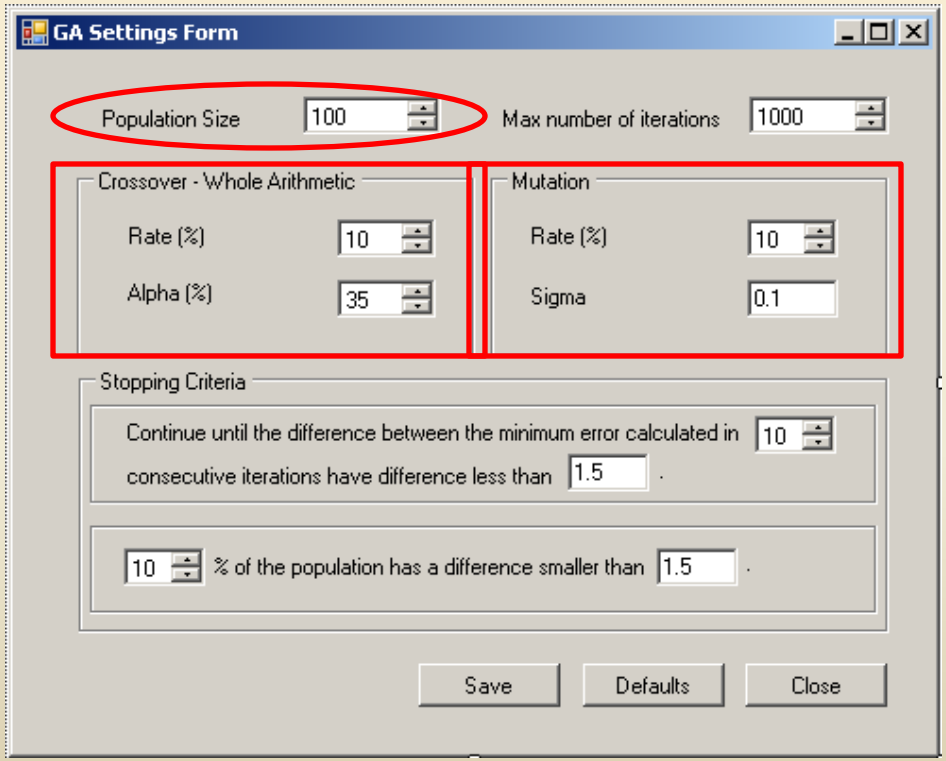
Heavy Traffic: 10 million or more.

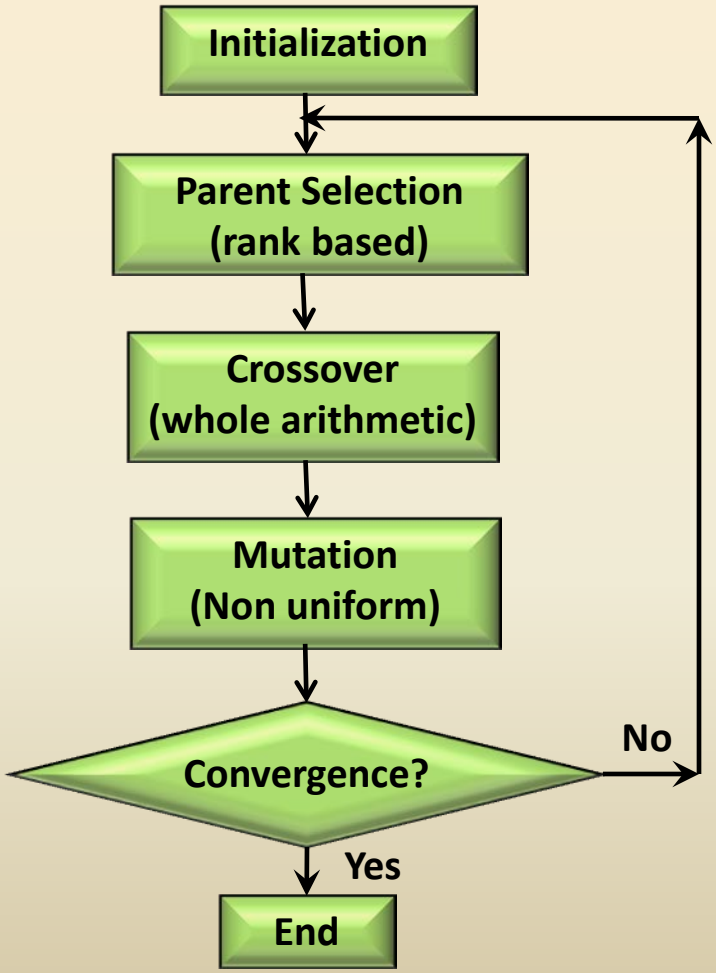
Model Calibration

- Determine the coefficient values (c_g) that minimize the difference between predicted performance (P_p) and actual performance (P_a).

$$\underset{x}{Minimize} \quad \sum_{g \in G} | P_p(c_g) - P_a |$$

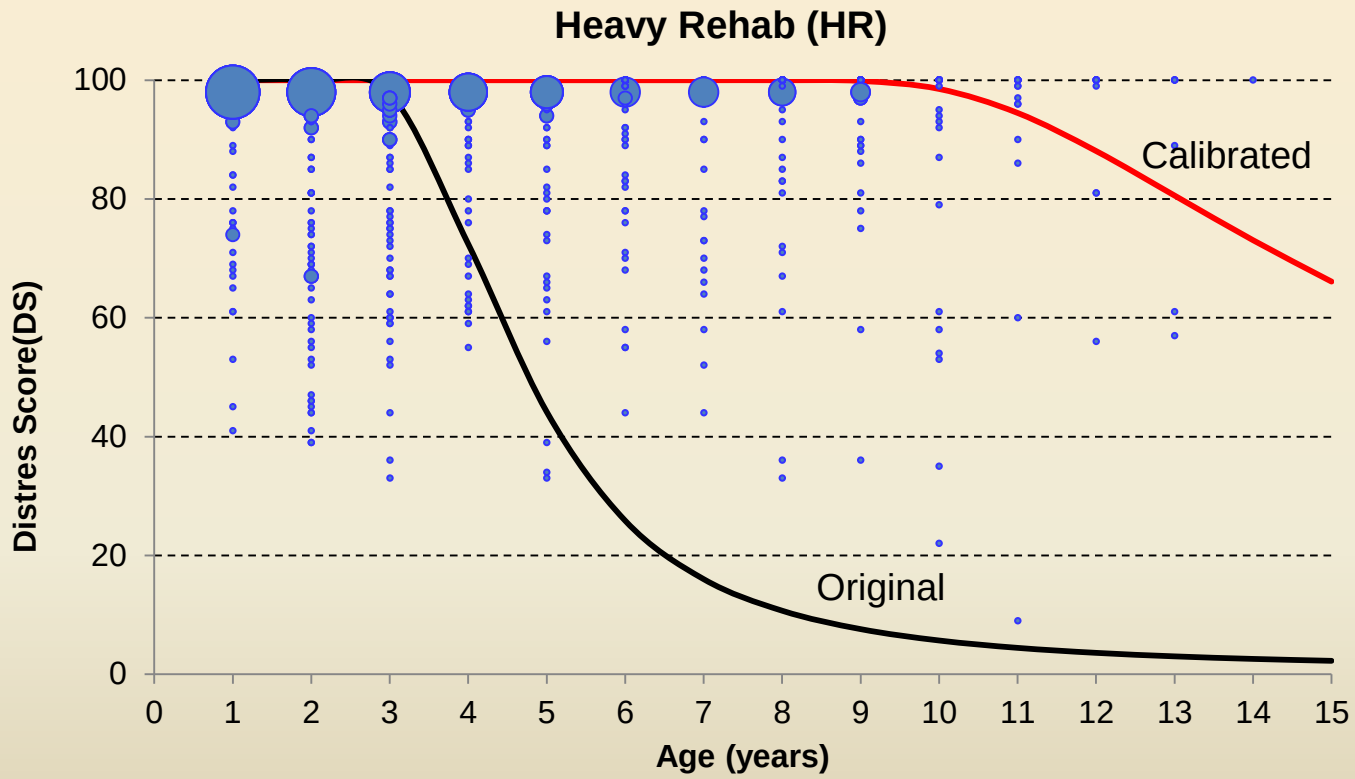
Genetic Algorithm for Model Calibration





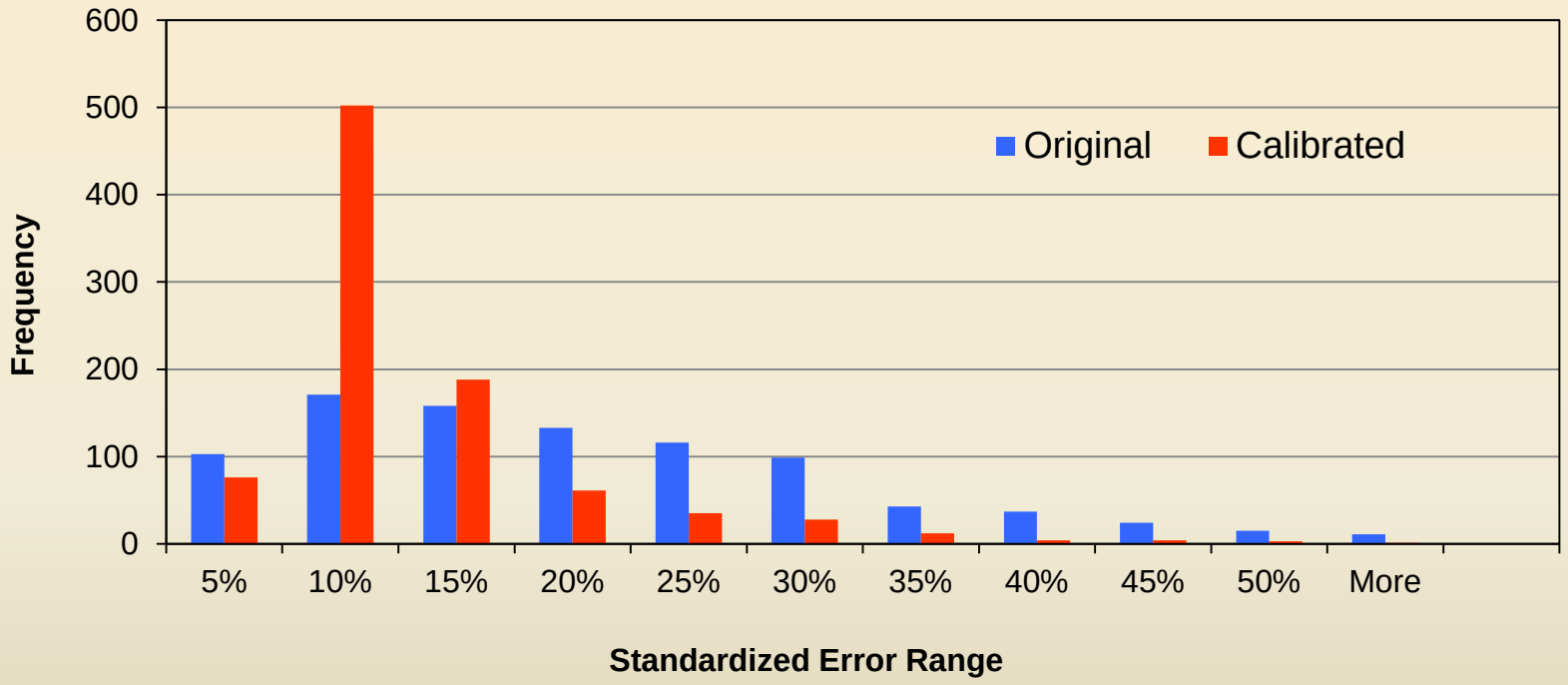
Zone 1 – Pavement Family A		Low Traffic			Medium Traffic			High Traffic		
Distress Type	**Treatment Type**	**α**	**β**	**A**	**α**	**β**	**A**	**α**	**β**	**A**
Shallow Rutting	Preventive Maintenance	100.00	0.41	75.16	100.00	0.43	102.38	100.00	0.39	58.34
	Light Maintenance	100.00	0.47	79.75	100.00	0.47	107.18	100.00	0.42	66.85
	Medium Rehabilitation	100.00	0.52	80.38	100.00	0.55	121.09	100.00	0.47	67.14
	Heavy Rehabilitation	100.00	0.53	91.69	100.00	0.58	122.99	100.00	0.55	70.69
Deep Rutting	Preventive Maintenance	100.00	0.54	88.24	100.00	0.76	60.35	100.00	0.58	95.02
	Light Maintenance	100.00	0.55	101.18	100.00	0.80	68.37	100.00	0.60	113.20
	Medium Rehabilitation	100.00	0.56	115.81	100.00	0.88	80.79	100.00	0.65	116.07
	Heavy Rehabilitation	100.00	0.57	133.23	100.00	1.01	83.07	100.00	0.73	123.10
Failures	Preventive Maintenance	20.00	1.11	23.48	20.00	1.30	19.85	20.00	3.61	8.86
	Light Maintenance	20.00	1.17	24.55	20.00	1.33	20.51	20.00	3.88	9.10
	Medium Rehabilitation	20.00	1.26	27.30	20.00	1.37	21.50	20.00	4.19	9.14
	Heavy Rehabilitation	20.00	1.40	30.05	20.00	1.40	21.49	20.00	4.54	9.18
Block Cracking	Preventive Maintenance	100.00	3.73	114.51	100.00	0.96	45.92	100.00	6.75	83.46
	Light Maintenance	100.00	3.81	130.91	100.00	1.83	47.93	100.00	7.69	94.98
	Medium Rehabilitation	100.00	4.46	142.20	100.00	2.58	48.74	100.00	8.80	108.82
	Heavy Rehabilitation	100.00	4.98	146.76	100.00	3.14	58.32	100.00	10.10	125.49
Alligator Cracking	Preventive Maintenance	100.00	0.58	101.42	100.00	0.49	96.93	100.00	4.24	8.20
	Light Maintenance	100.00	0.62	104.61	100.00	0.53	113.11	100.00	5.10	9.67
	Medium Rehabilitation	100.00	0.72	115.98	100.00	0.58	133.61	100.00	5.73	11.28
	Heavy Rehabilitation	100.00	0.73	135.90	100.00	0.65	159.49	100.00	6.06	11.90
Longitudinal Cracking	Preventive Maintenance	500.00	0.52	116.51	500.00	0.53	90.24	500.00	0.44	69.52
	Light Maintenance	500.00	0.60	133.63	500.00	0.54	104.52	500.00	0.50	71.55
	Medium Rehabilitation	500.00	0.67	146.86	500.00	0.56	123.32	500.00	0.51	81.25
	Heavy Rehabilitation	500.00	0.71	153.66	500.00	0.59	146.45	500.00	0.58	84.37
Transverse Cracking	Preventive Maintenance	20.00	0.71	95.12	20.00	0.49	68.47	20.00	0.88	20.33
	Light Maintenance	20.00	1.11	109.50	20.00	0.54	68.87	20.00	0.92	21.07
	Medium Rehabilitation	20.00	1.52	125.33	20.00	0.55	77.01	20.00	0.99	22.61
	Heavy Rehabilitation	20.00	1.95	143.04	20.00	0.61	78.23	20.00	1.09	25.68
Patching	Preventive Maintenance	100.00	0.38	101.23	100.00	0.64	49.65	100.00	0.52	87.67
	Light Maintenance	100.00	0.41	105.68	100.00	0.65	53.60	100.00	0.52	100.95
	Medium Rehabilitation	100.00	0.48	119.25	100.00	0.65	57.65	100.00	0.53	115.41
	Heavy Rehabilitation	100.00	0.50	119.67	100.00	0.78	61.64	100.00	0.54	131.59

Calibrated & Original DS Prediction Model
(Example — Zone 1, Pavement Family A, Medium Traffic)



(Zone 1, Pavement Family A, & HR)
(Number of data points (n)= 1647; Average 20-year ESALs = 4.74 million)

Assessment of Model Error



Original Models Avg. Error = ± 20%
Calibrated Models Avg. Error = ± 8%

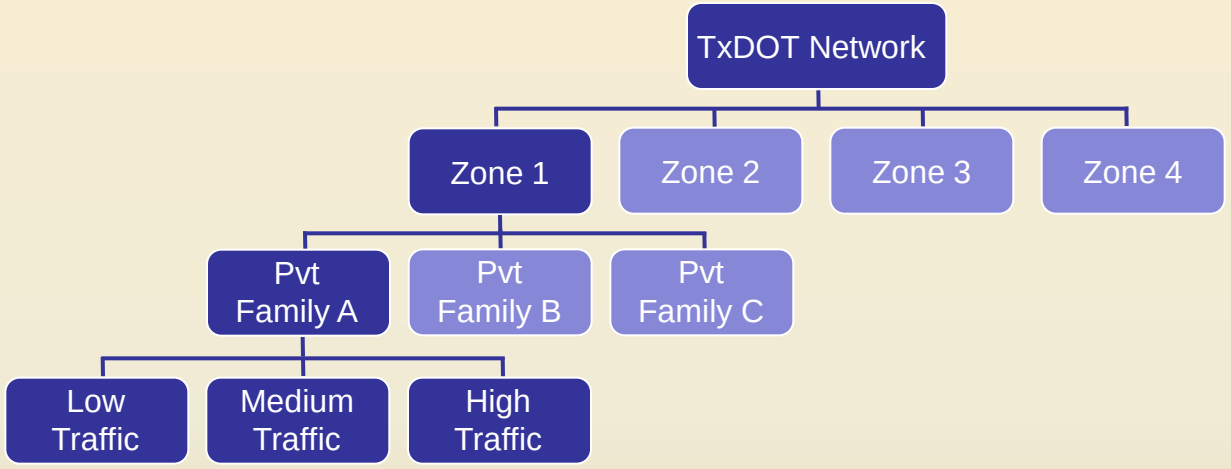
Findings

- The original models exhibited a pattern of predicting higher distress values (and consequently lower DS values) than the observed data.
- The calibrated models predict less pavement deterioration compared to the original models.
- On average, the calibrated models have an error of ±8%; whereas the original models have an average error of ±20%.
- The calibrated models ensure logical performance superiority pattern across treatment types.

In The Web Survey...

We will review the proposed models

- Starting with Zone 1...
- Going to Family A...
- And going through each Traffic group



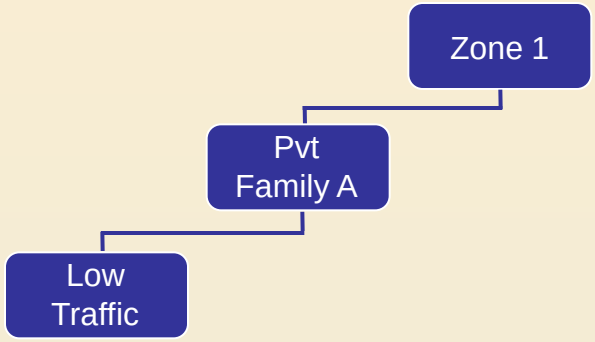
1-A-Low → 1-A-Medium → 1-A-High

then 1-B-Low → 1-B-Medium → 1-B-High

then 1-C-Low → 1-C-Medium → 1-C-High

In The Web Survey...

Each group (for example, 1-A-Low) will have 19 slides:



1-4 Distress Score Curves
- PM, LR, MR, HR
- Proposed compared to existing

5 Distress Score Curves
- All treatments on one slide

6-9 Distress Curves
- PM, LR, MR, HR
- Proposed only

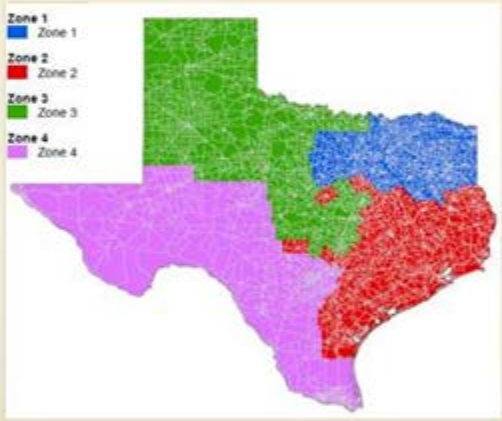
★ We are asking you to review the zone(s) in which your district is located. Depending on your district, this will include one or maybe two zones.

Calibration of PMIS Pavement Performance Prediction Models

Conducted as part of TxDOT Project 0-6386

Zone 1, Pvt Family A

Zone 1:
wet-cold climate, and poor, very poor, or mixed subgrade.



Pavement Family A:

- Thick ACP (PMIS Pavement Type 4)
- Intermediate ACP (PMIS Pavement Type 5)
- Overlaid ACP (PMIS Pavement Type 9)

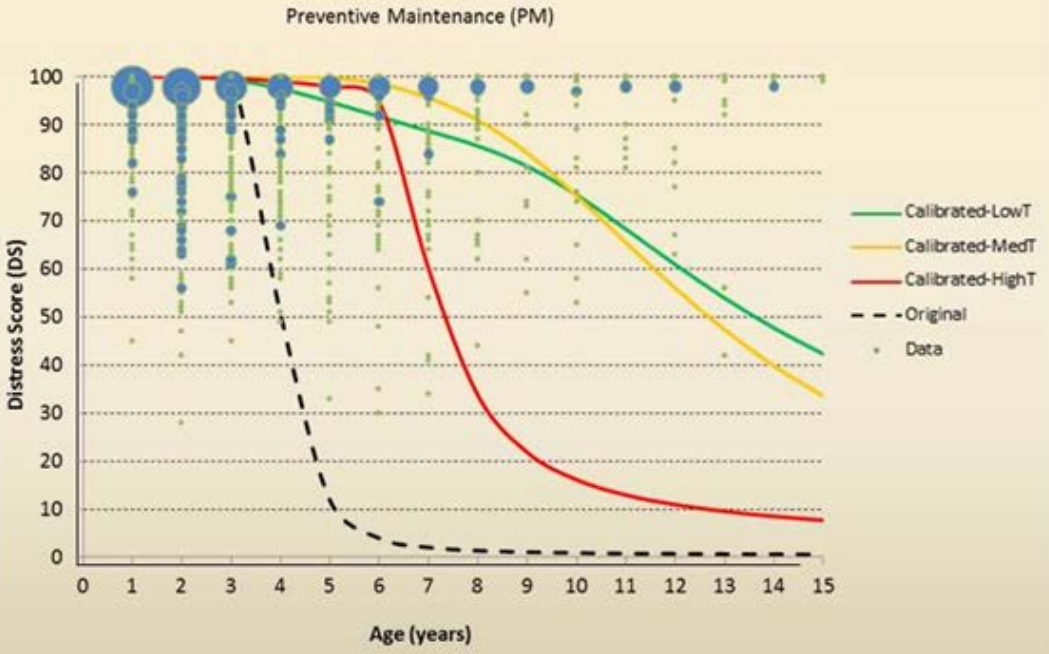
Age_0:The age when distress first appears
Age_{70}:The age when DS drops into 70
DS_{15}:DS at the age of 15 years

Zone 1, Pvt Family A

Districts
PAR
FTW
DAL
TYL
ATL

Traffic Curve	Data Points		
	Age_0	Age_{70}	DS_{15}
Low	3	11	43
Medium	5	11	34
High	4	6.5	8

Thick, medium or overlaid ACP



Number of data points (n)= 2068; Average 20-year ESALs = 5.12 million

3

	Highly Overpredicts (Should be moved down and left)	Slightly Overpredicts (Should be moved down and left)	Reasonable	Slightly Underpredicts (Should be moved up and right)	Highly Underpredicts (Should be moved up and right)
High Traffic	○	○	○	○	○
Medium Traffic	○	○	○	○	○
Low Traffic	○	○	○	○	○

Any Suggestions?

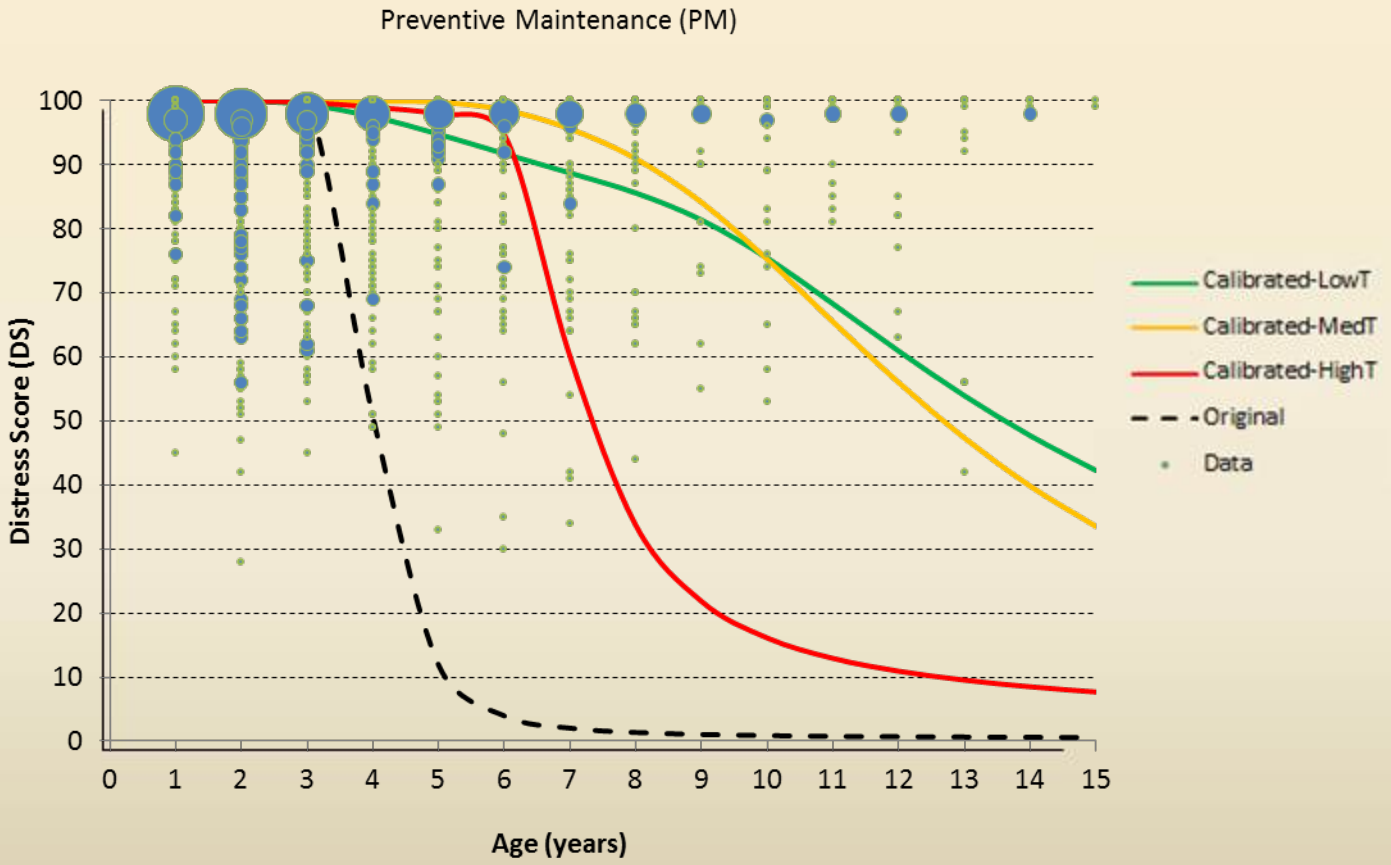
More Sample Slides

Zone 1, Pvt Family A
(Example — Slide #1)

Districts
PAR
FTW
DAL
TYL
ATL

Traffic Curve	Critical Age & DS Points		
	Age_0	Age_{70}	DS_{15}
Low	3	11	43
Medium	5	11	34
High	4	6.5	8

Thick, medium or overlaid ACP

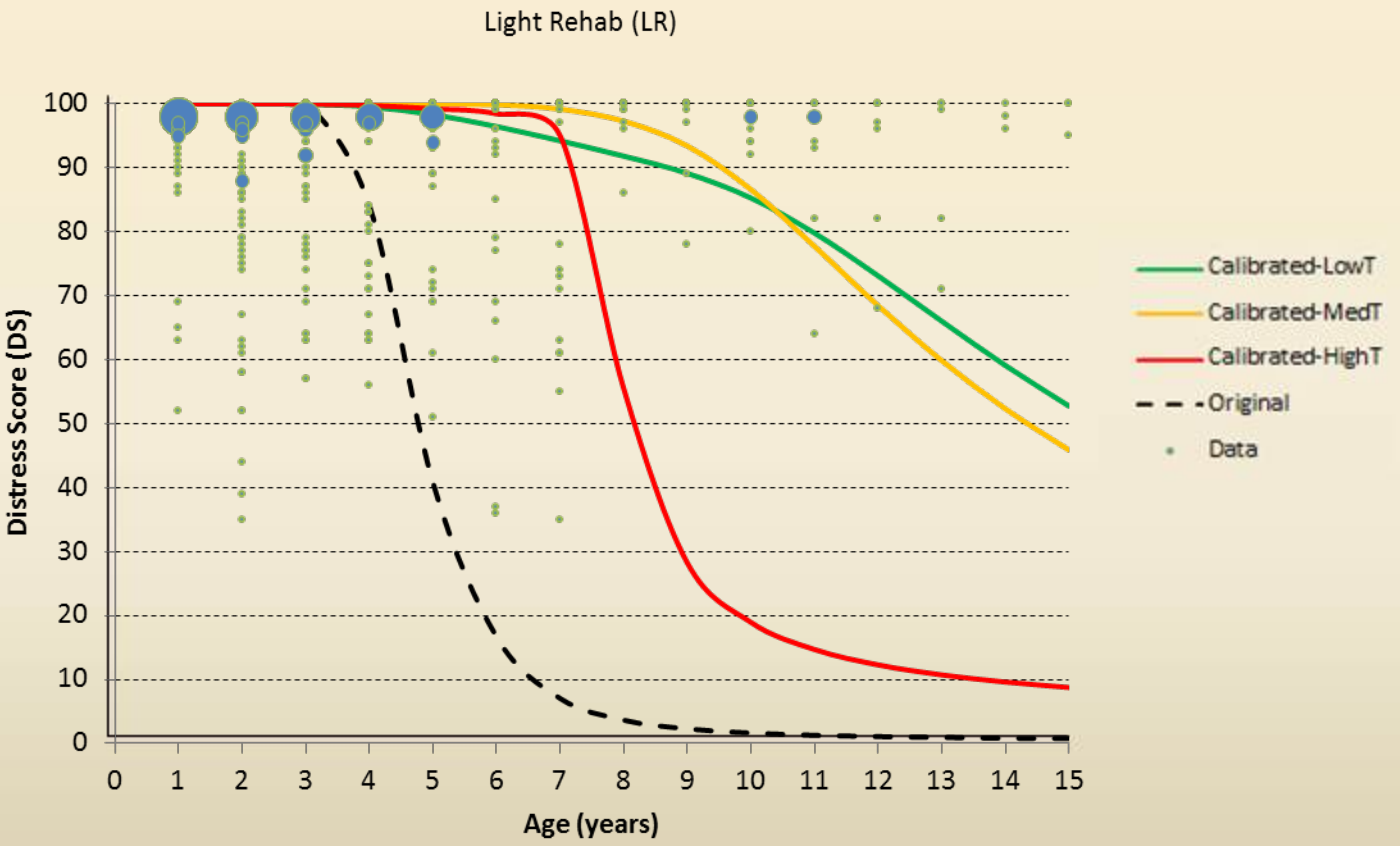


Number of data points (n)= 2068; Average 20-year ESALs = 5.12 million

Zone 1, Pvt Family A
(Example — Slide #2)

Districts
PAR
FTW
DAL
TYL
ATL

Traffic Curve	Critical Age & DS Points		
	Age_0	Age_{70}	DS_{15}
Low	4	12.5	53
Medium	6	11.5	46
High	5	7.5	9



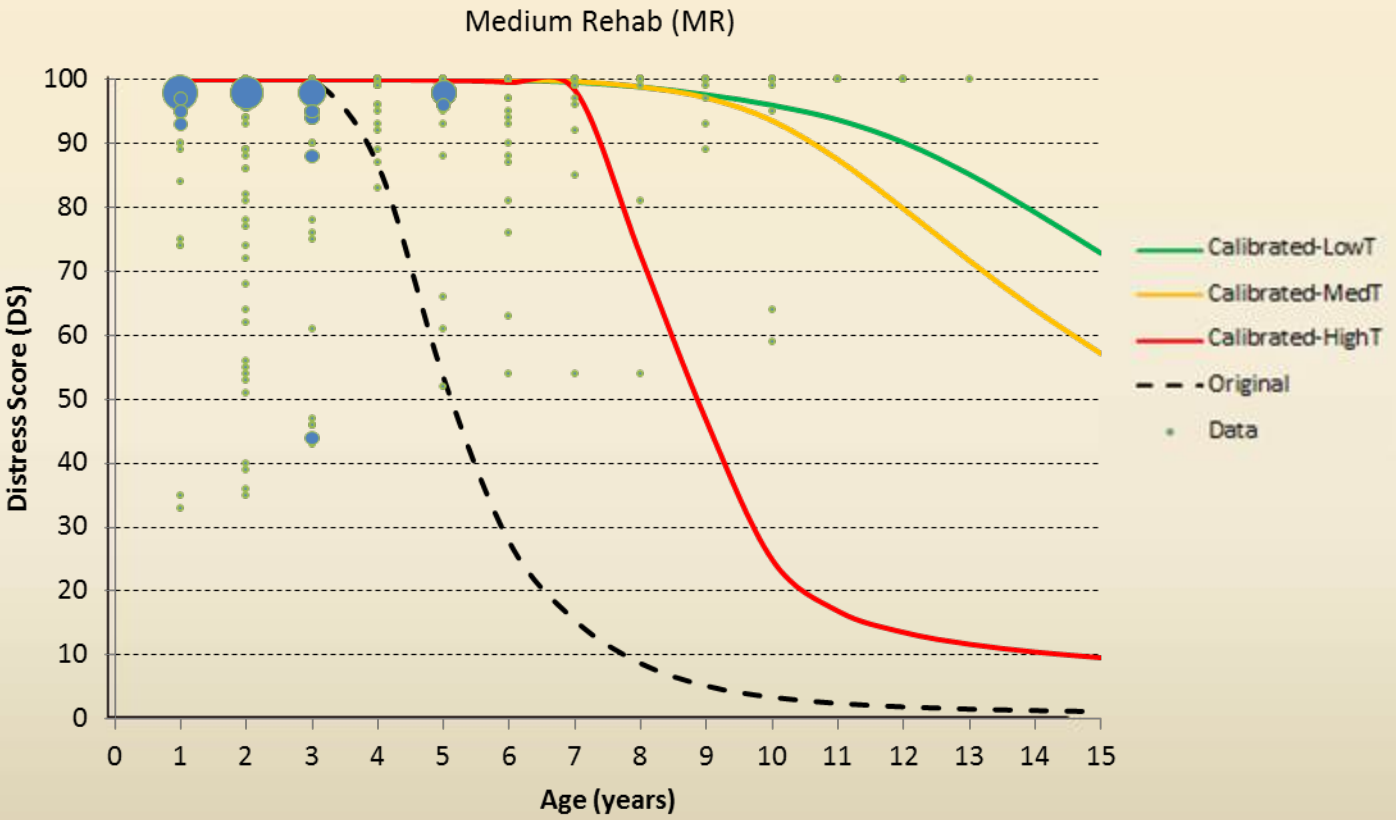
Thick, medium or overlaid ACP

Number of data points (n)= 742; Average 20-year ESALs = 6.83 million

Zone 1, Pvt Family A
(Example — Slide #3)

Districts
PAR
FTW
DAL
TYL
ATL

Traffic Curve	Critical Age & DS Points		
	Age_0	Age_{70}	DS_{15}
Low	7	> 15	74
Medium	7	13	57
High	7	8	10



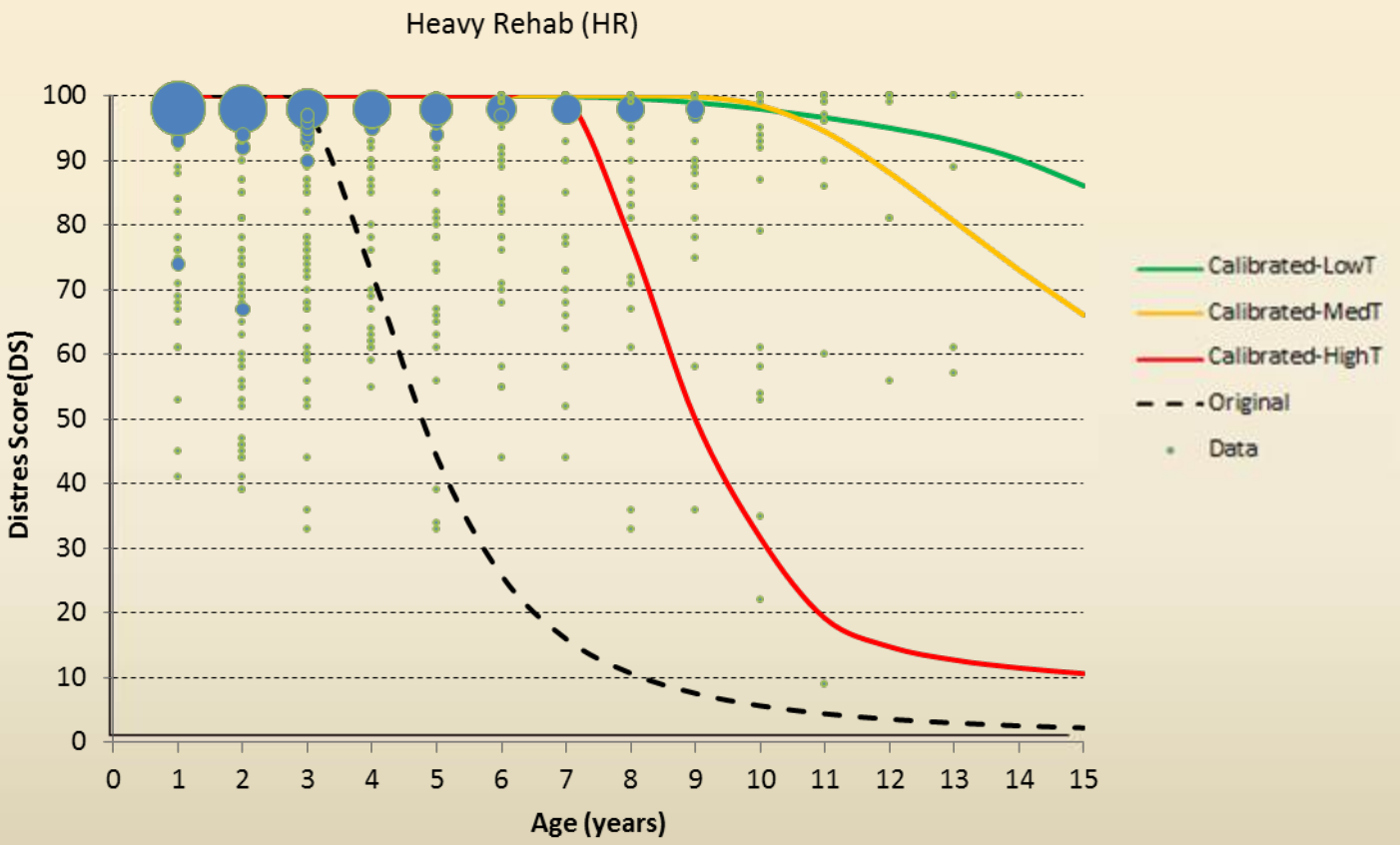
Thick, medium or overlaid ACP

Number of data points (n)= 647; Average 20-year ESALs = 5.82 million

Zone 1, Pvt Family A
(Example — Slide #4)

Districts
PAR
FTW
DAL
TYL
ATL

Traffic Curve	Critical Age & DS Points		
	Age_0	Age_{70}	DS_{15}
Low	8	> 15	86
Medium	8	14.5	66
High	7	9	10

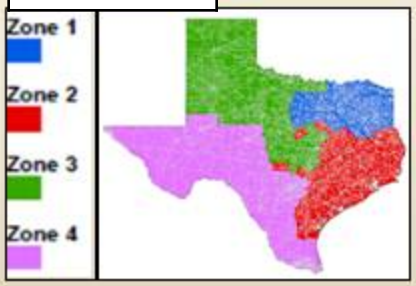


Thick, medium or overlaid ACP

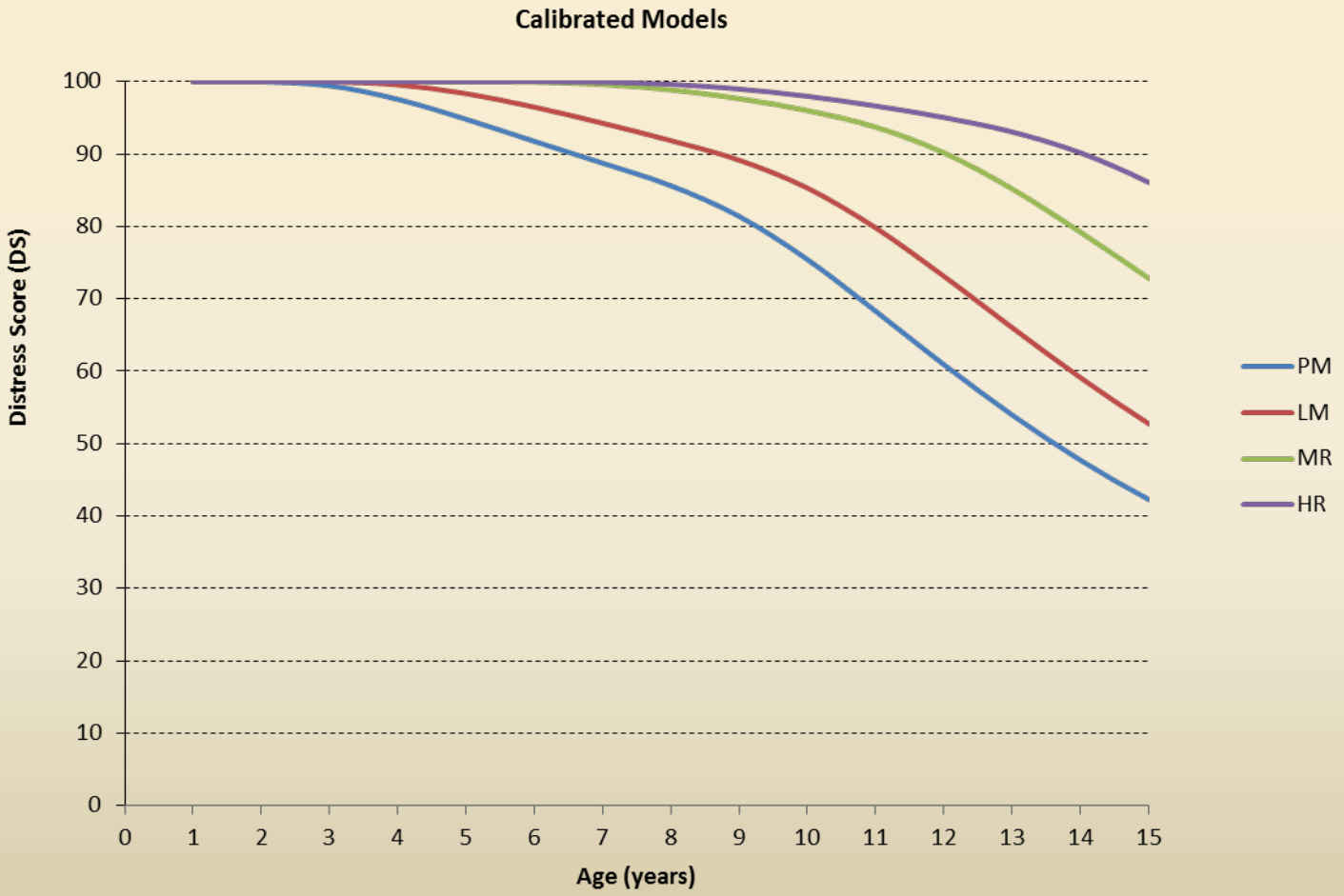
Number of data points (n)= 1647; Average 20-year ESALs = 4.74 million

Zone 1, Pvt Family A and Low Traffic
(Example — Slide #5)

Districts
PAR
FTW
DAL
TYL
ATL

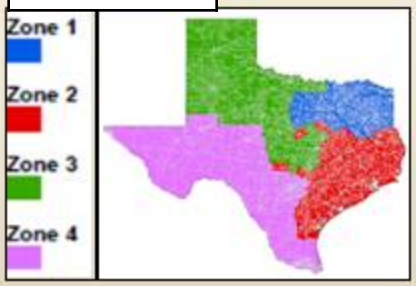


Thick, medium or overlaid ACP

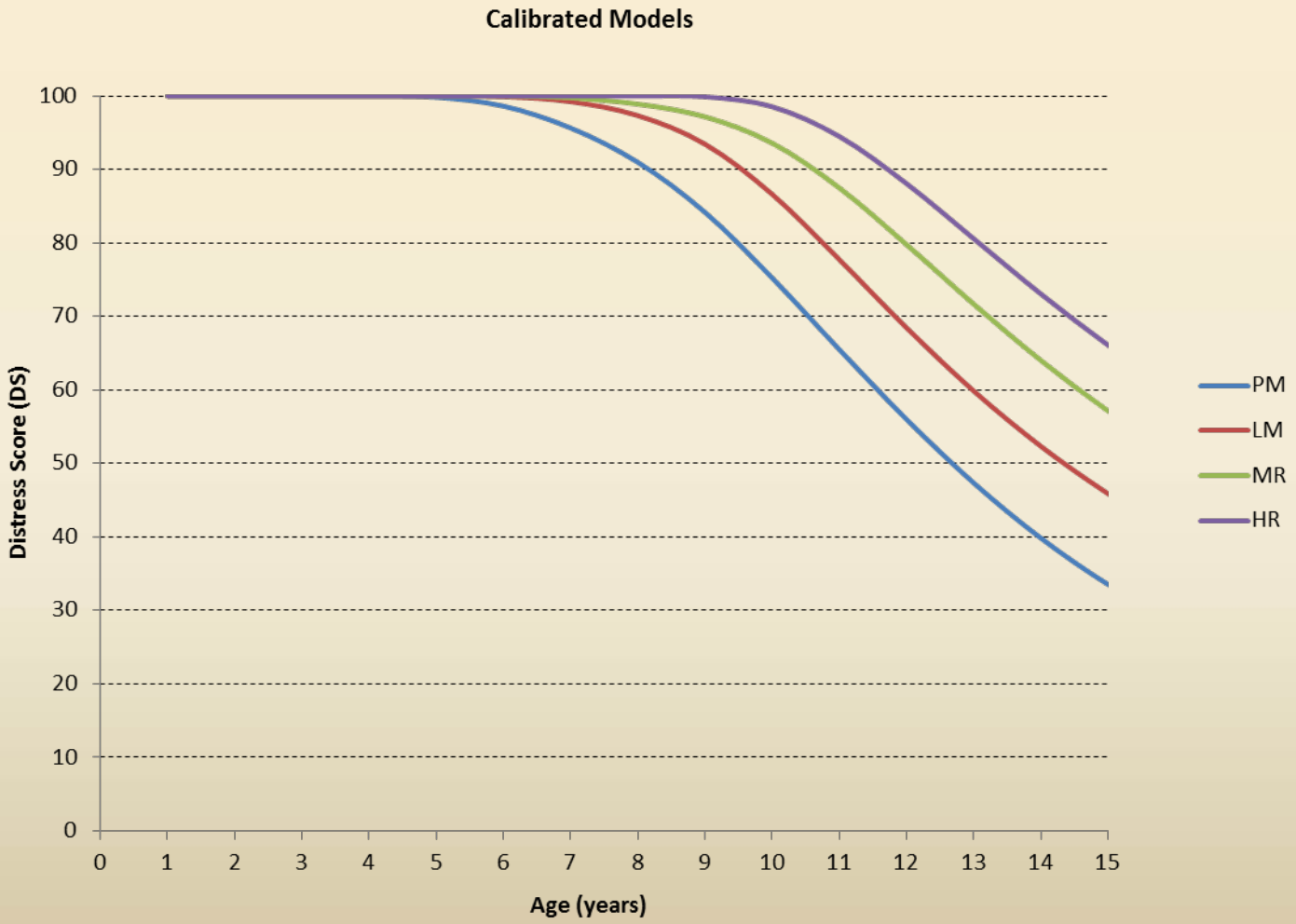


Zone 1, Pvt Family A and Medium Traffic
(Example — Slide #6)

Districts
PAR
FTW
DAL
TYL
ATL

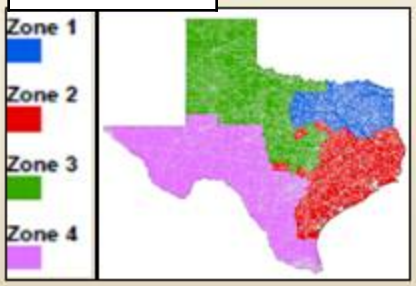


Thick, medium or overlaid ACP

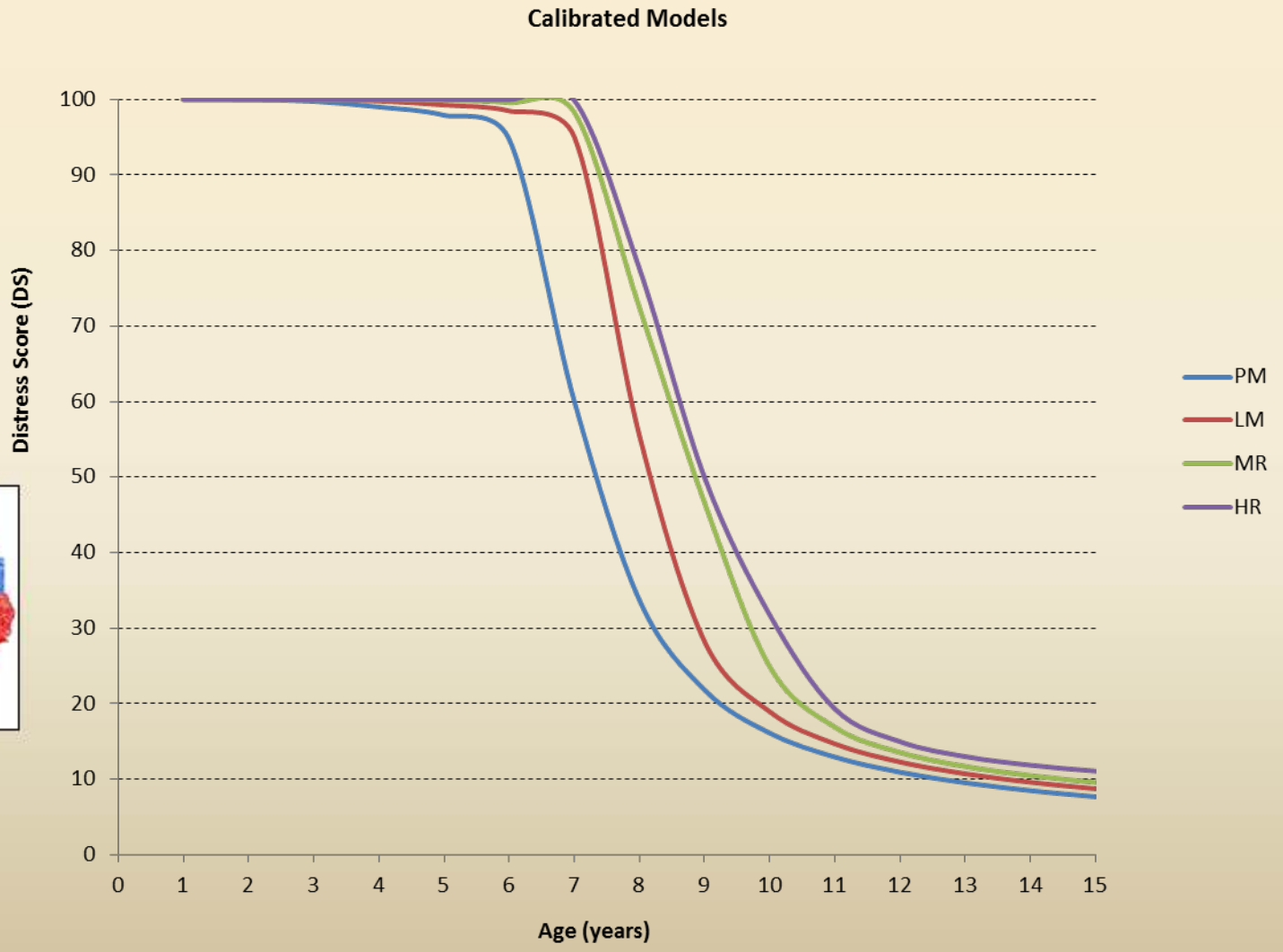


Zone 1, Pvt Family A and High Traffic
(Example — Slide #7)

Districts
PAR
FTW
DAL
TYL
ATL

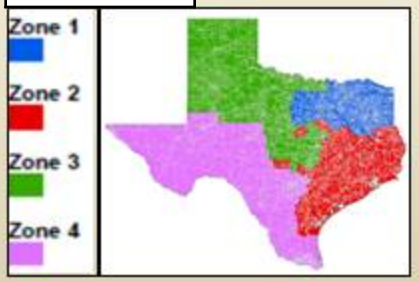


Thick, medium or overlaid ACP

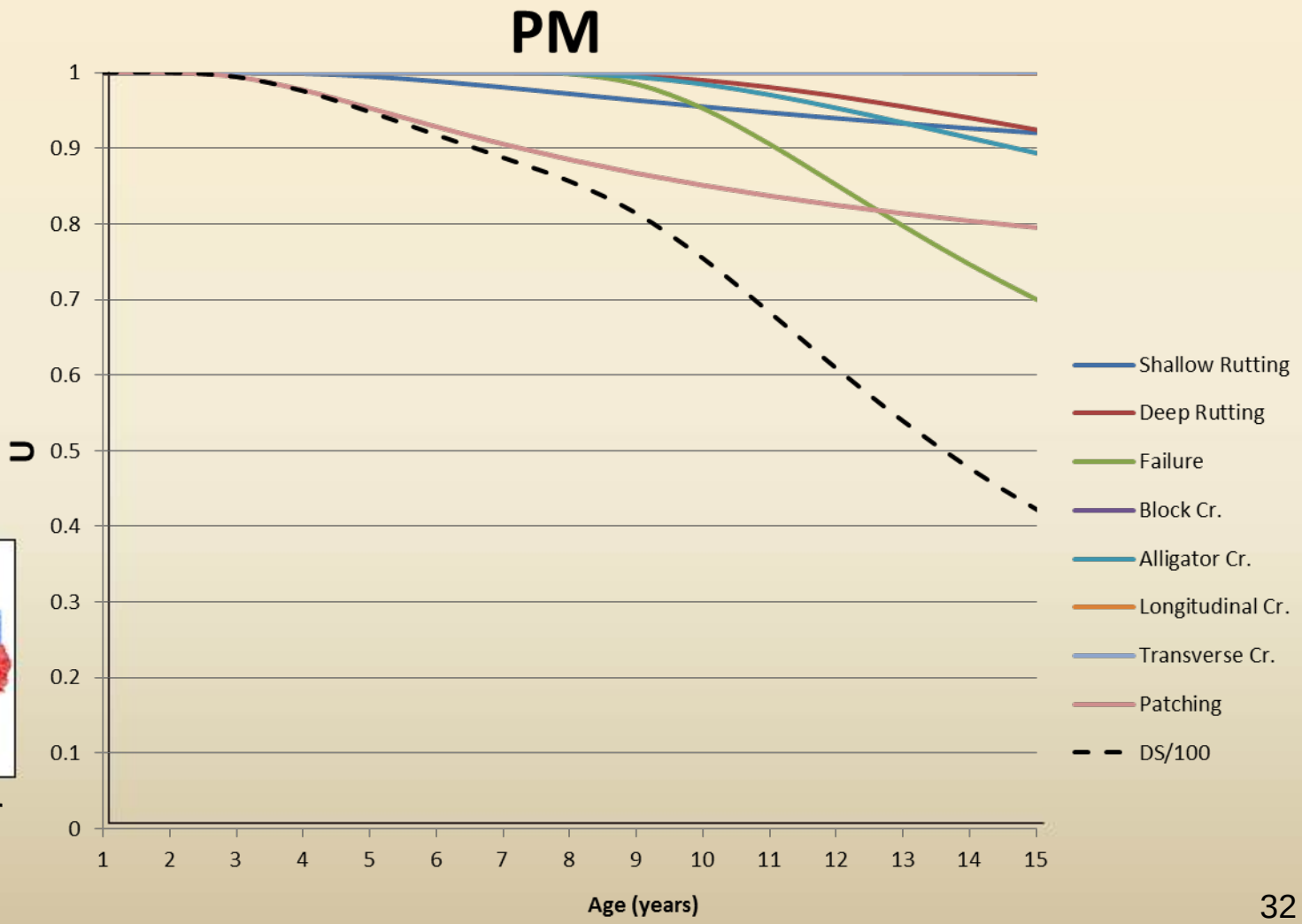


Zone 1, Pvt Family A and Low Traffic
(Example — Slide #8)

Districts
PAR
FTW
DAL
TYL
ATL

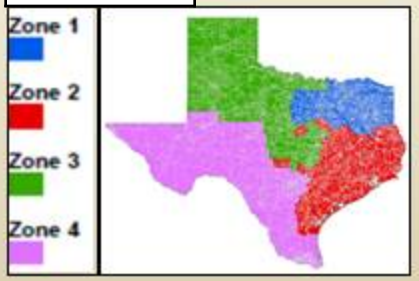


Thick, medium or overlaid ACP

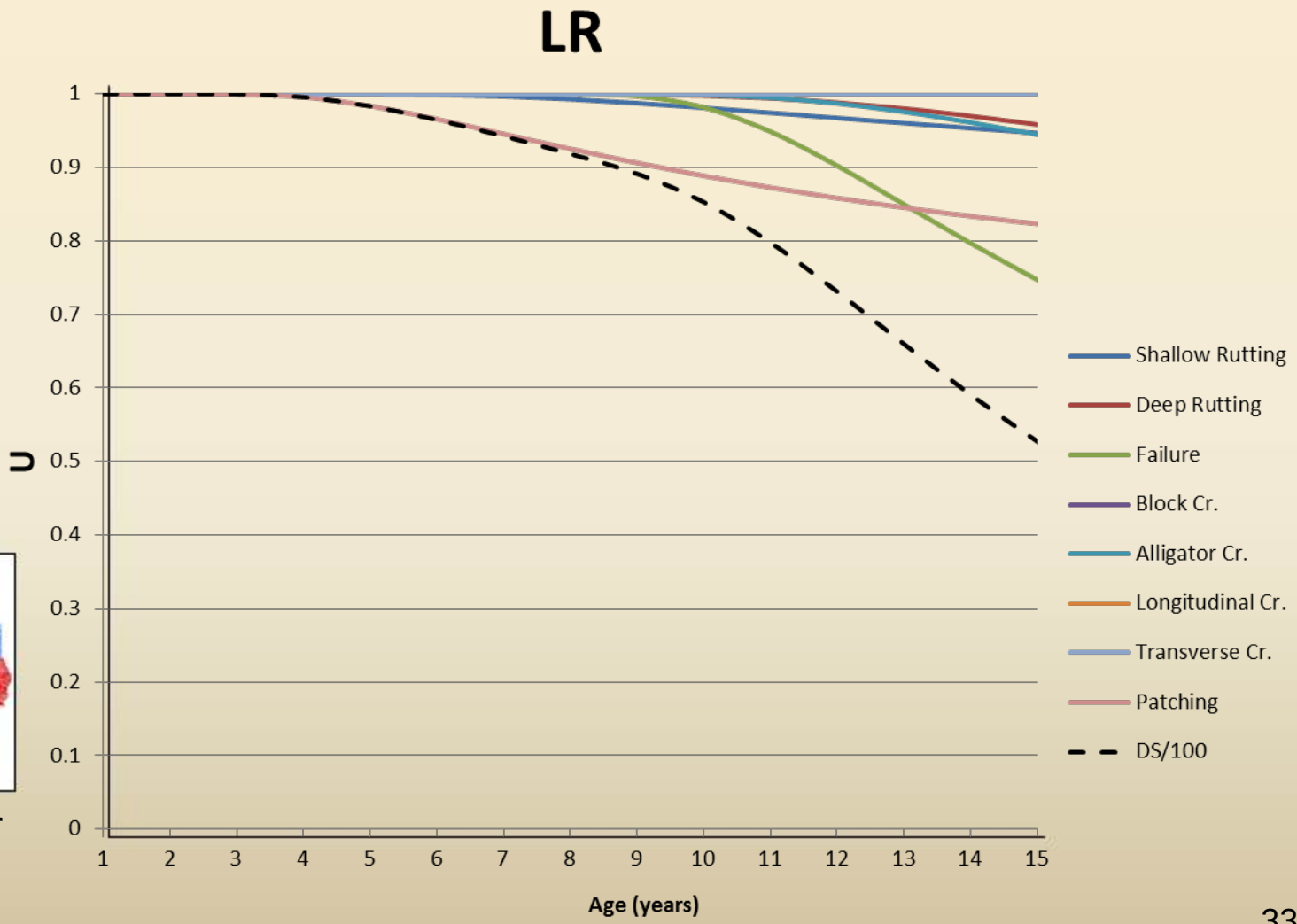


Zone 1, Pvt Family A and Low Traffic
(Example — Slide #9)

Districts
PAR
FTW
DAL
TYL
ATL

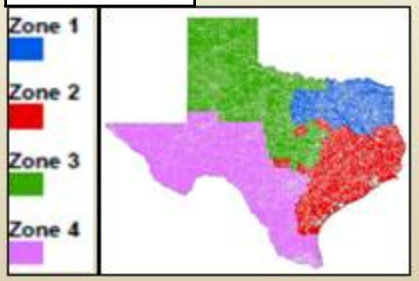


Thick, medium or overlaid ACP

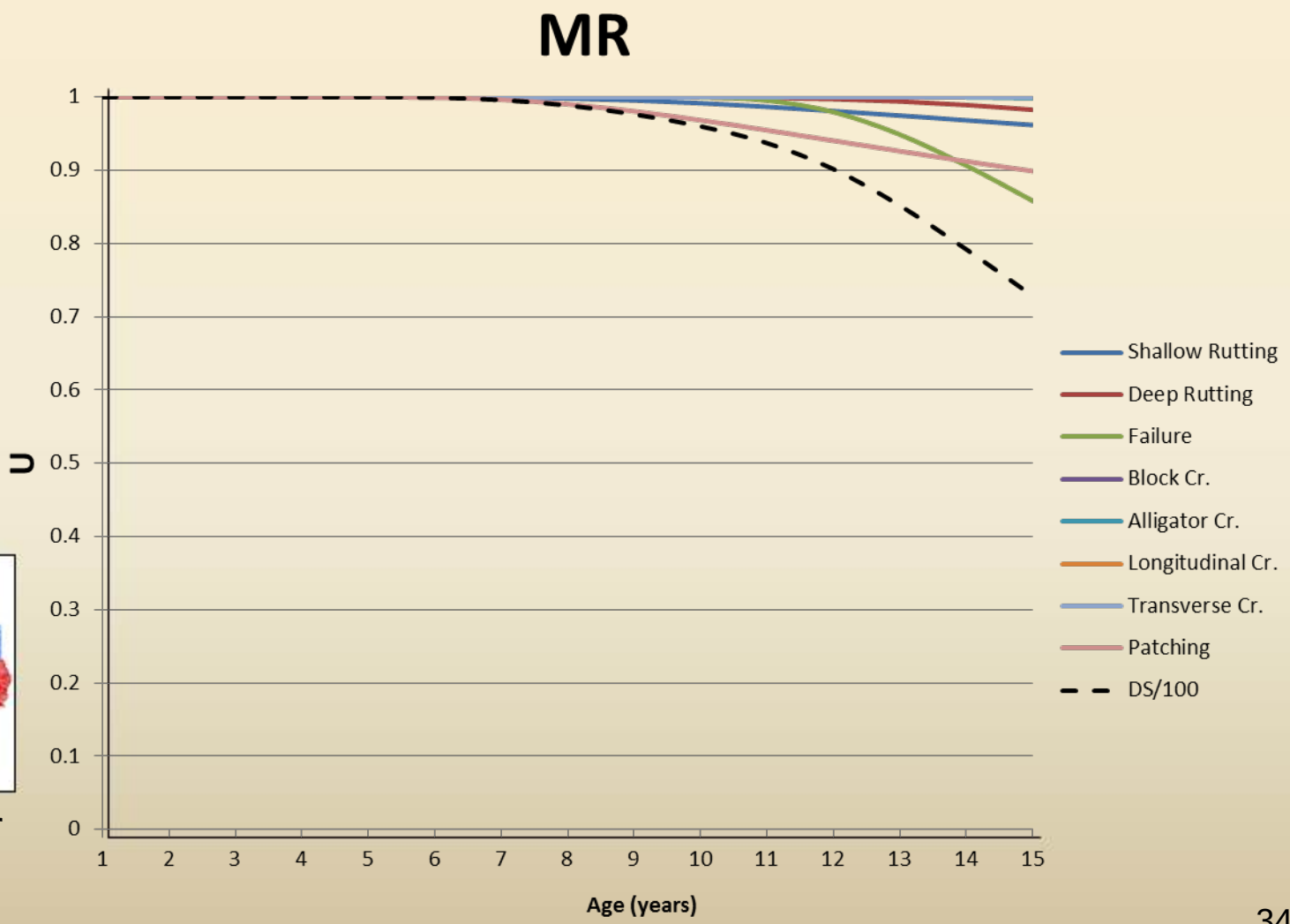


Zone 1, Pvt Family A and Low Traffic
(Example — Slide #10)

Districts
PAR
FTW
DAL
TYL
ATL

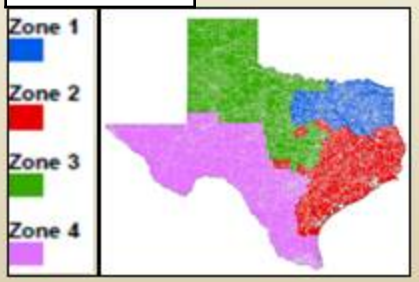


Thick, medium or overlaid ACP

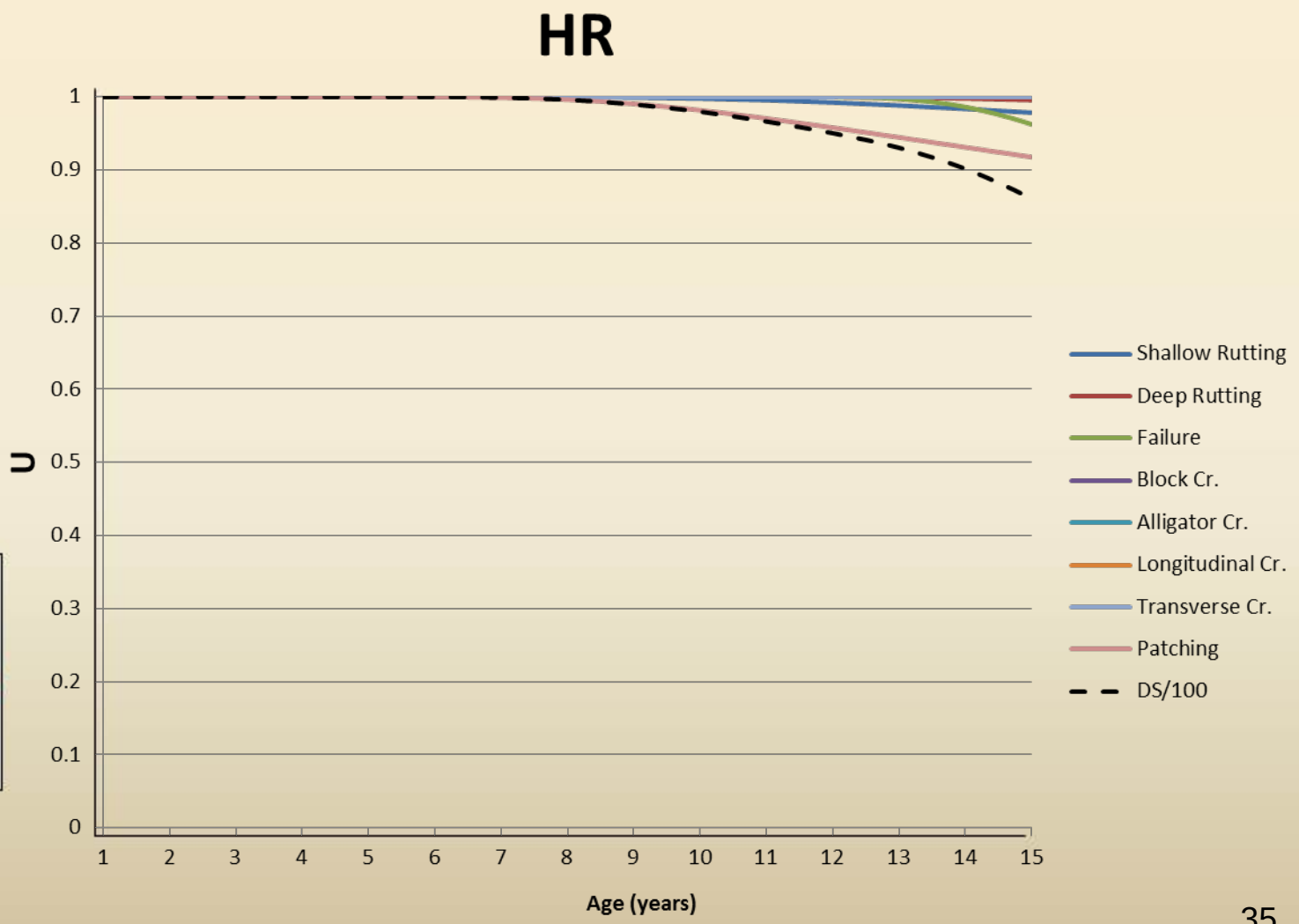


Zone 1, Pvt Family A and Low Traffic
(Example — Slide #11)

Districts
PAR
FTW
DAL
TYL
ATL

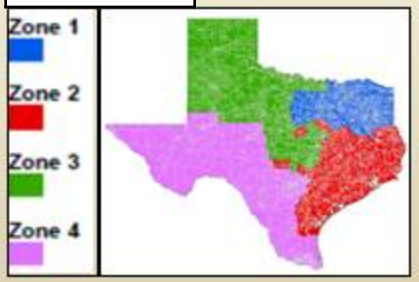


Thick, medium or overlaid ACP

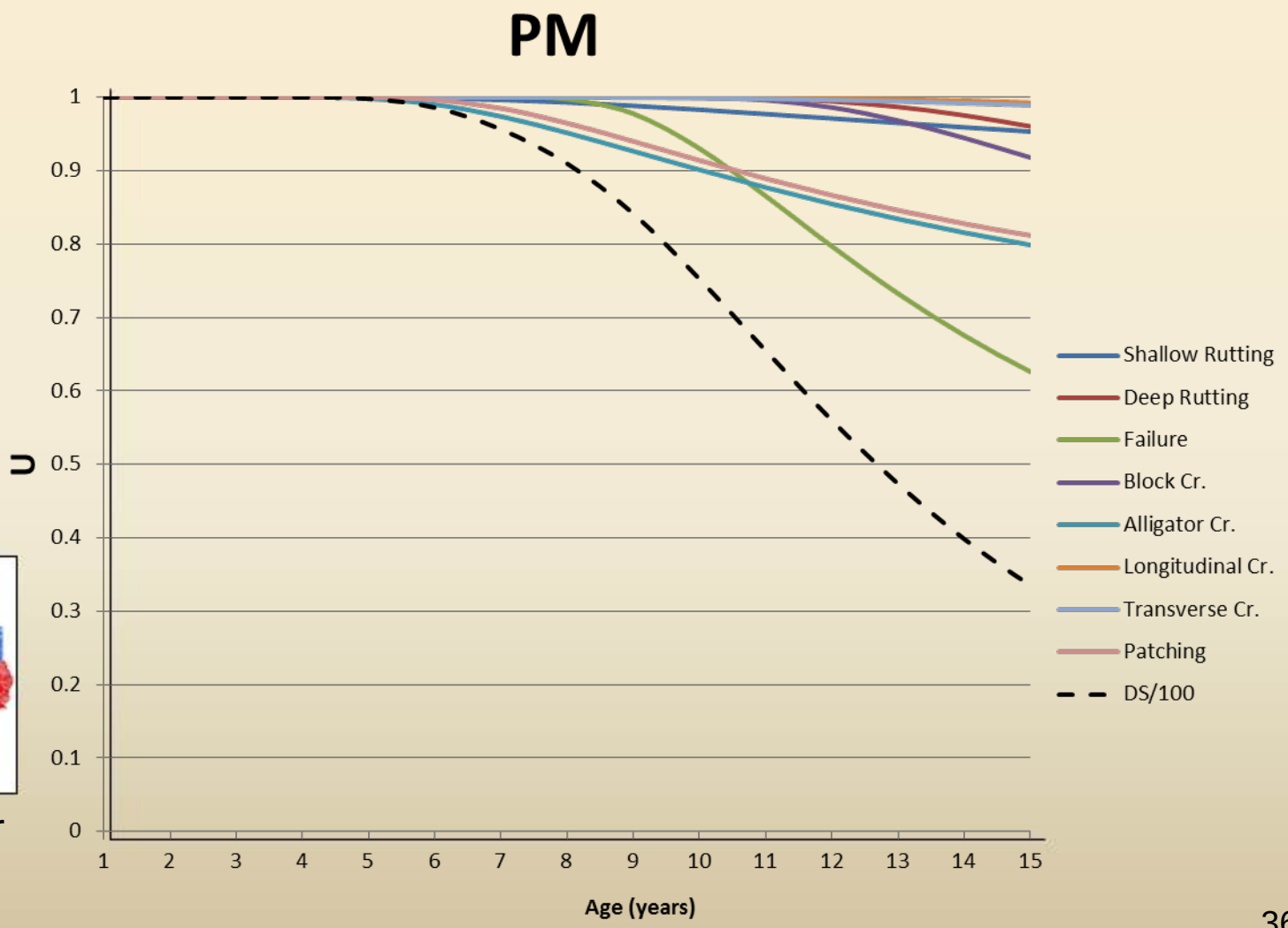


Zone 1, Pvt Family A and Medium Traffic
(Example — Slide #12)

Districts
PAR
FTW
DAL
TYL
ATL

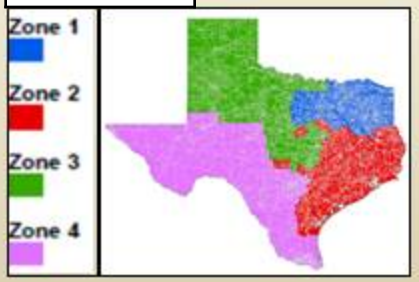


Thick, medium or overlaid ACP

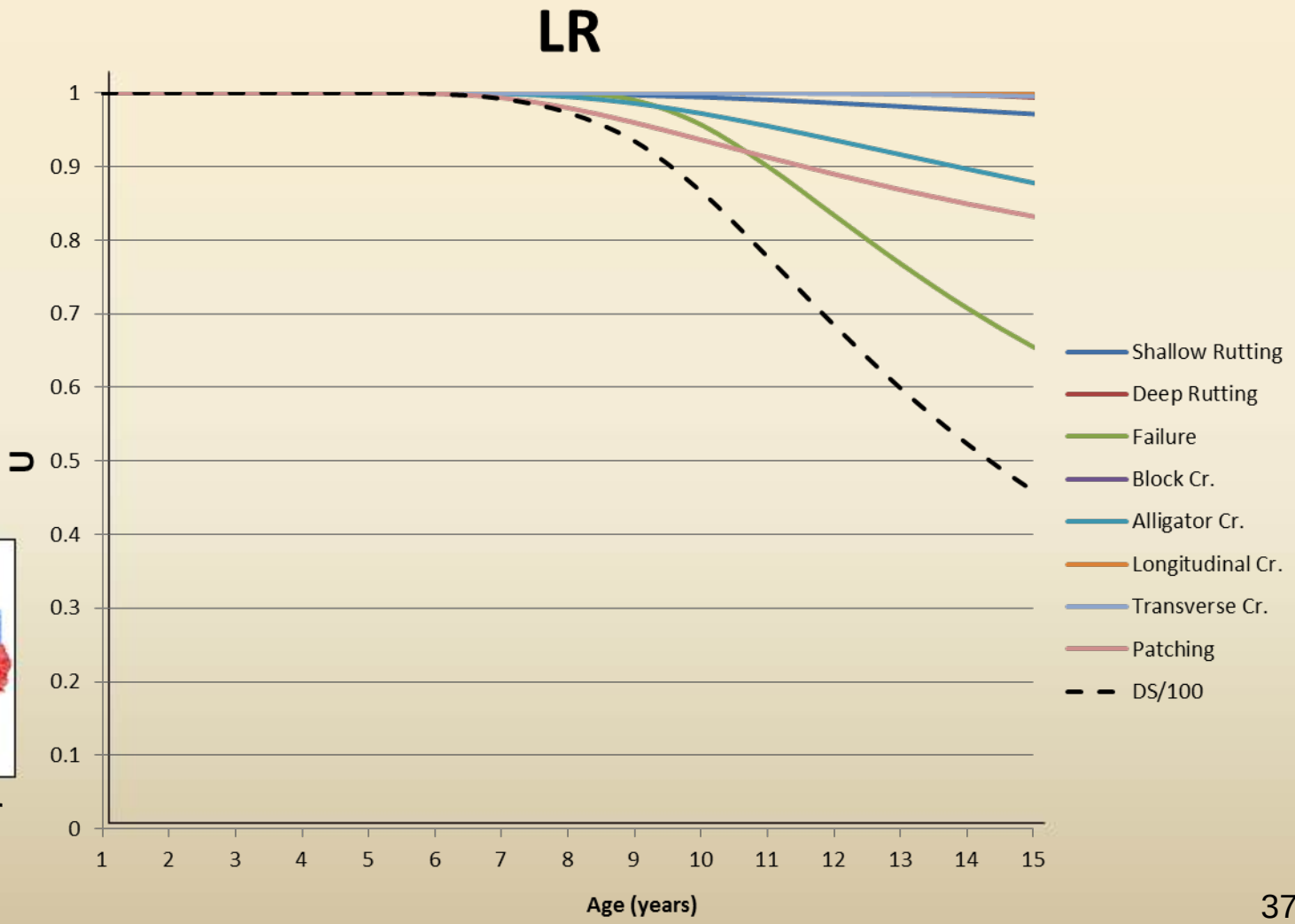


Zone 1, Pvt Family A and Medium Traffic
(Example — Slide #13)

Districts
PAR
FTW
DAL
TYL
ATL

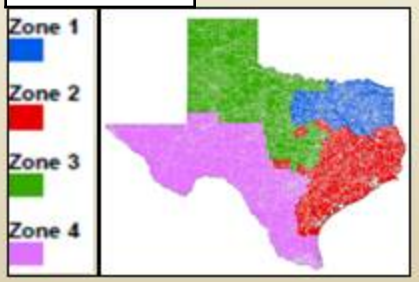


Thick, medium or overlaid ACP

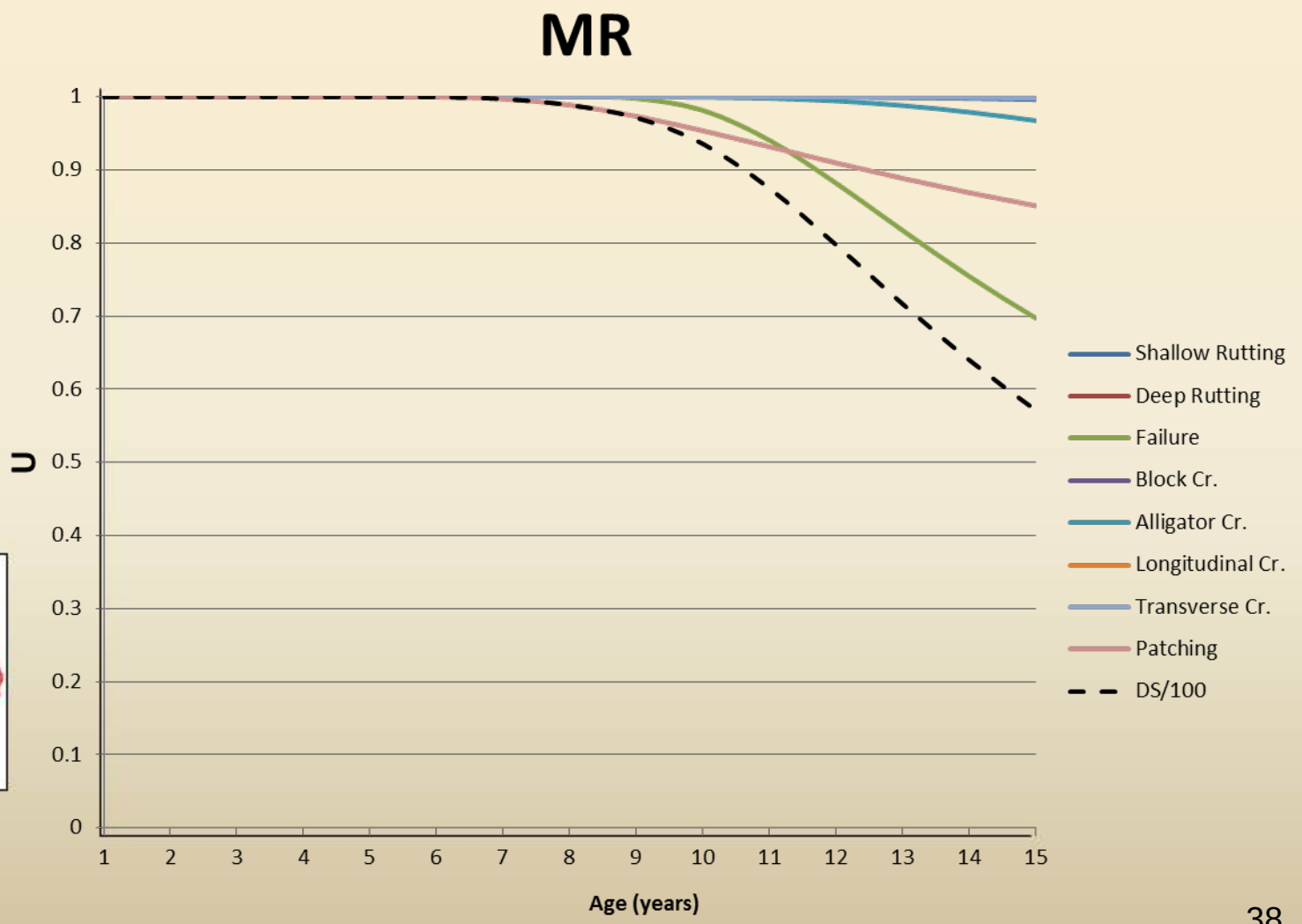


Zone 1, Pvt Family A and Medium Traffic
(Example — Slide #14)

Districts
PAR
FTW
DAL
TYL
ATL

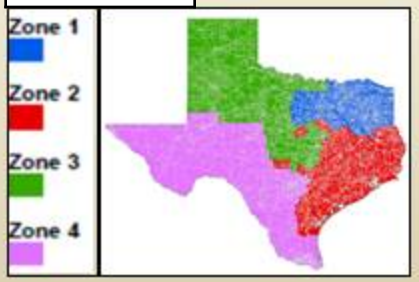


Thick, medium or overlaid ACP

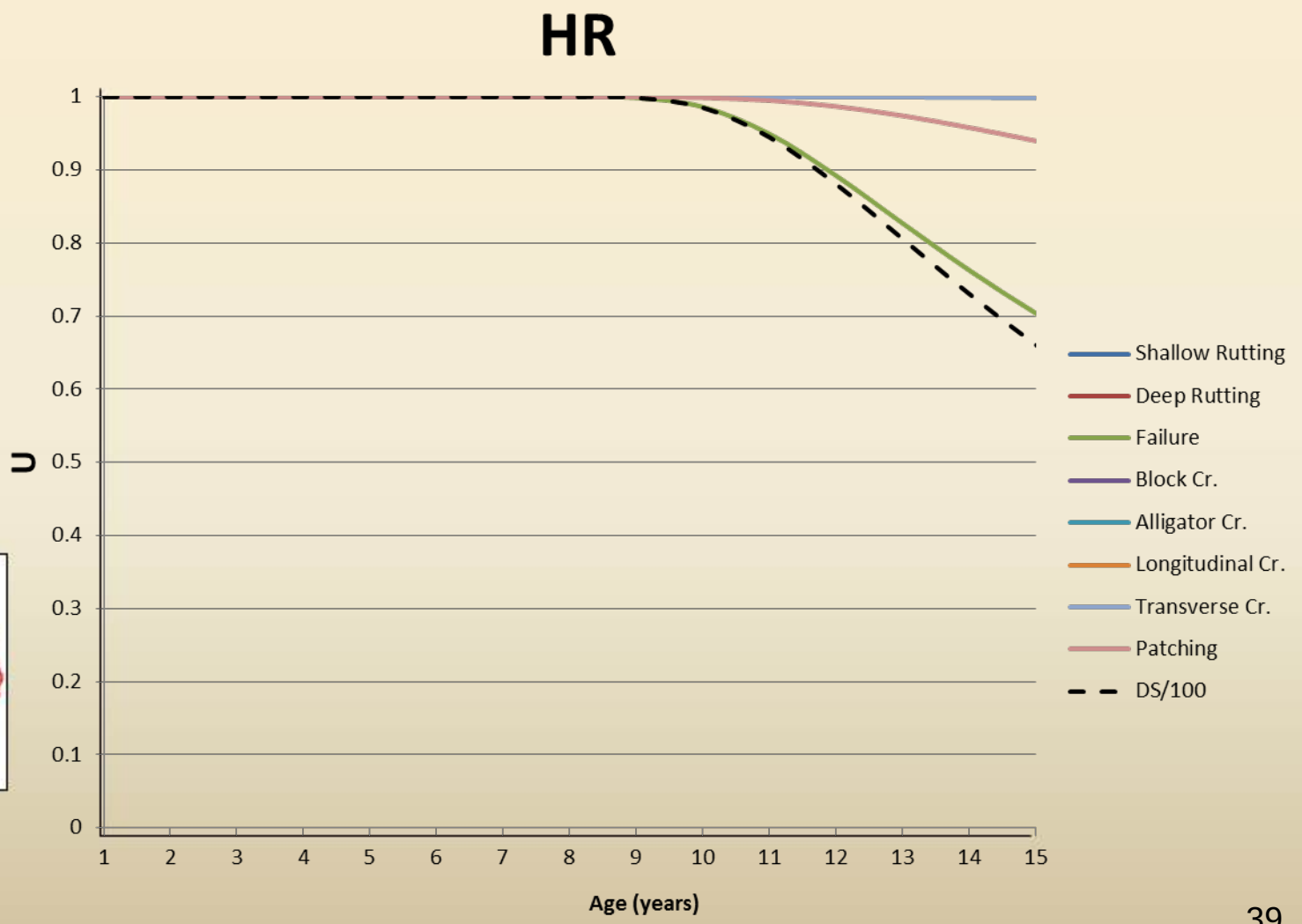


Zone 1, Pvt Family A and Medium Traffic
(Example — Slide #15)

Districts
PAR
FTW
DAL
TYL
ATL

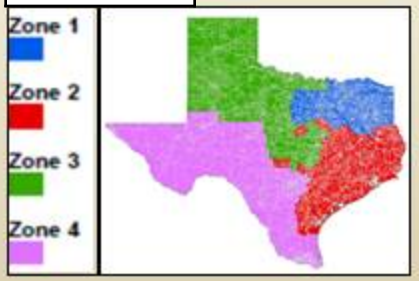


Thick, medium or overlaid ACP

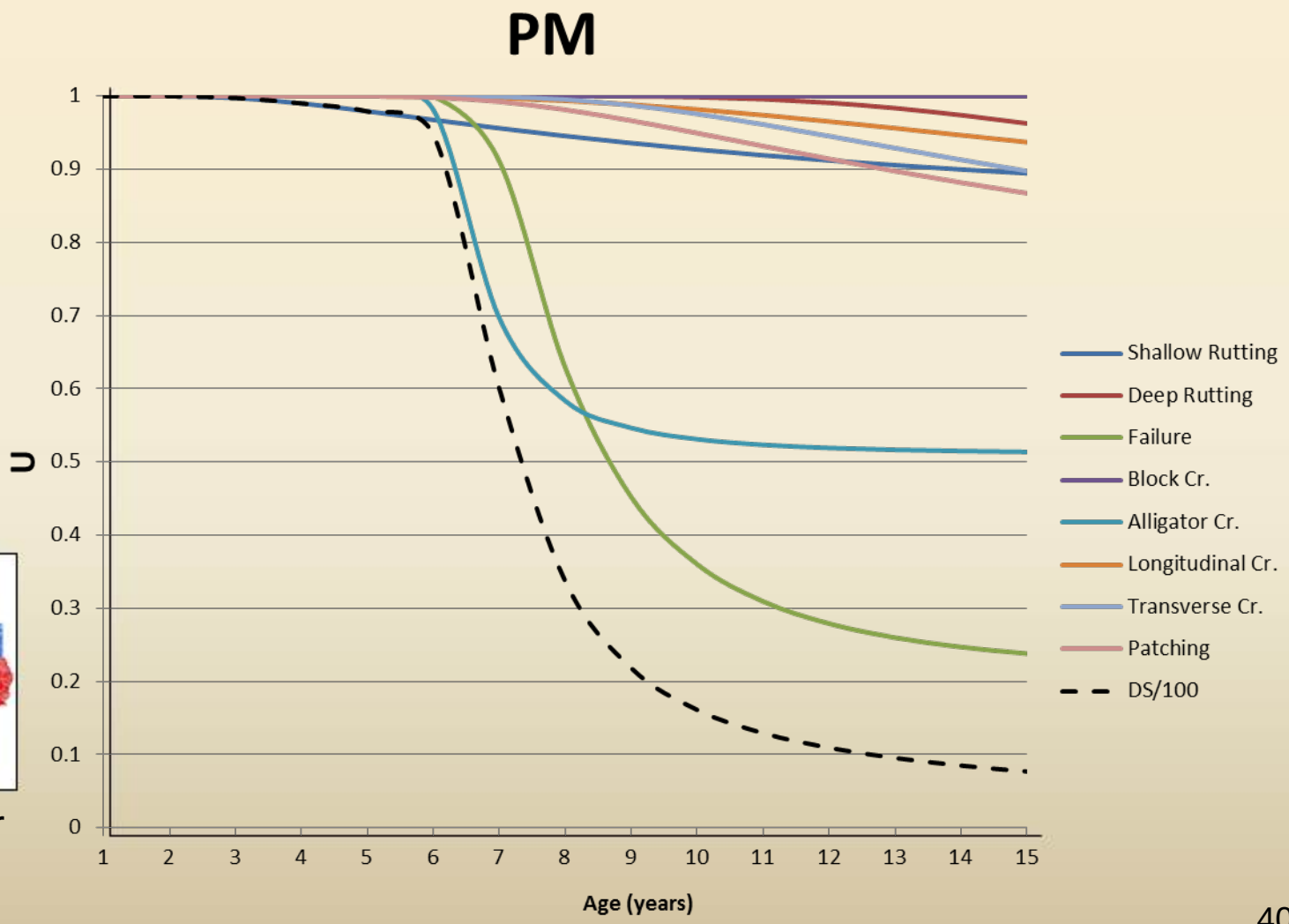


Zone 1, Pvt Family A and High Traffic
(Example — Slide #16)

Districts
PAR
FTW
DAL
TYL
ATL

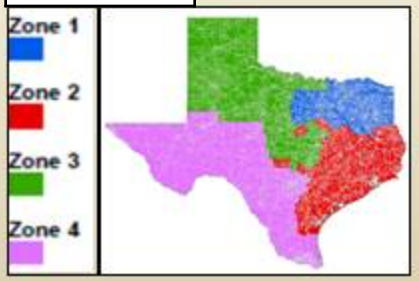


Thick, medium or overlaid ACP

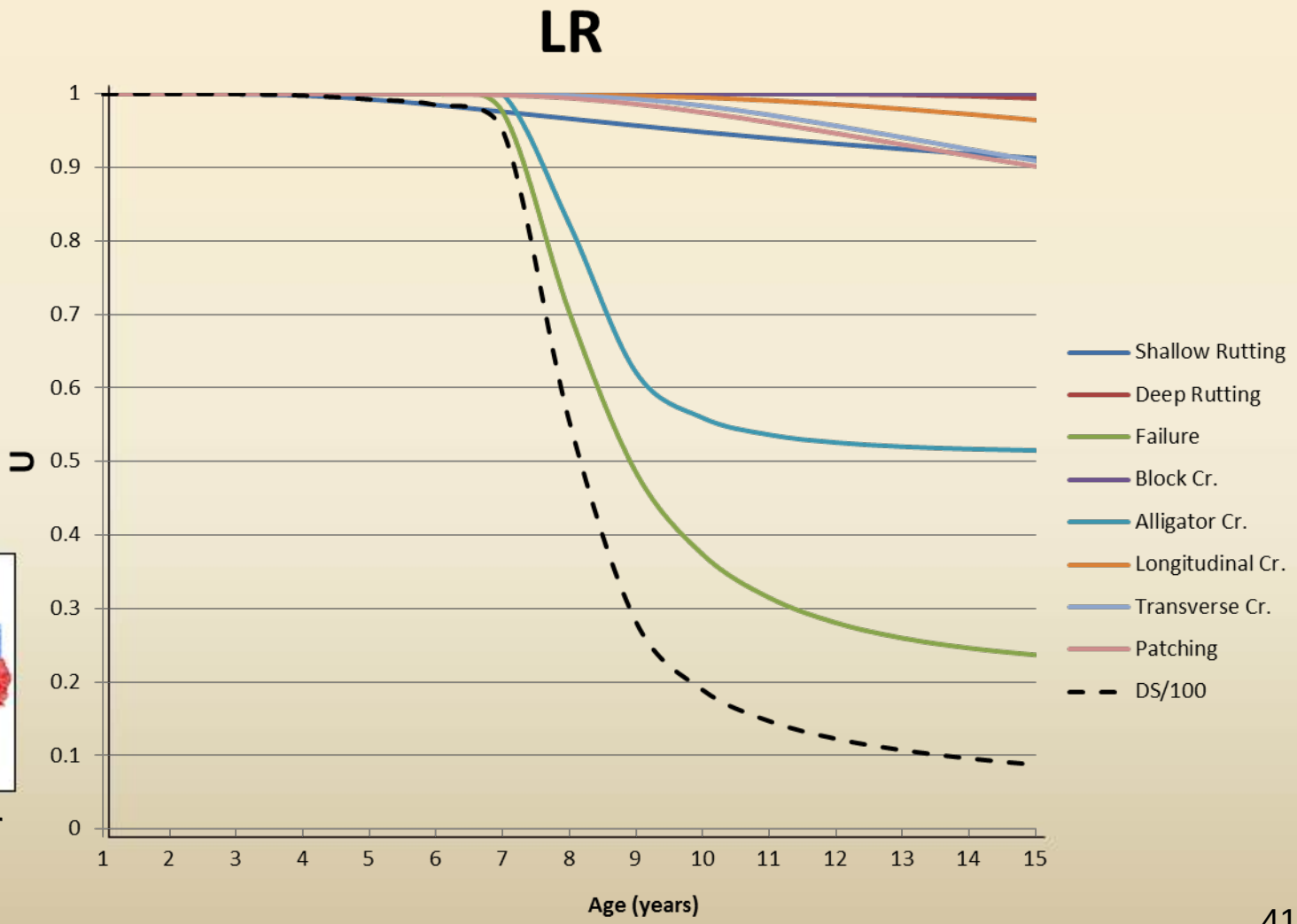


Zone 1, Pvt Family A and High Traffic
(Example — Slide #17)

Districts
PAR
FTW
DAL
TYL
ATL

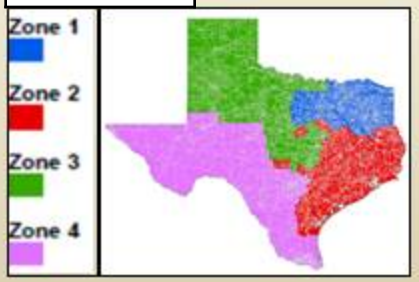


Thick, medium or overlaid ACP

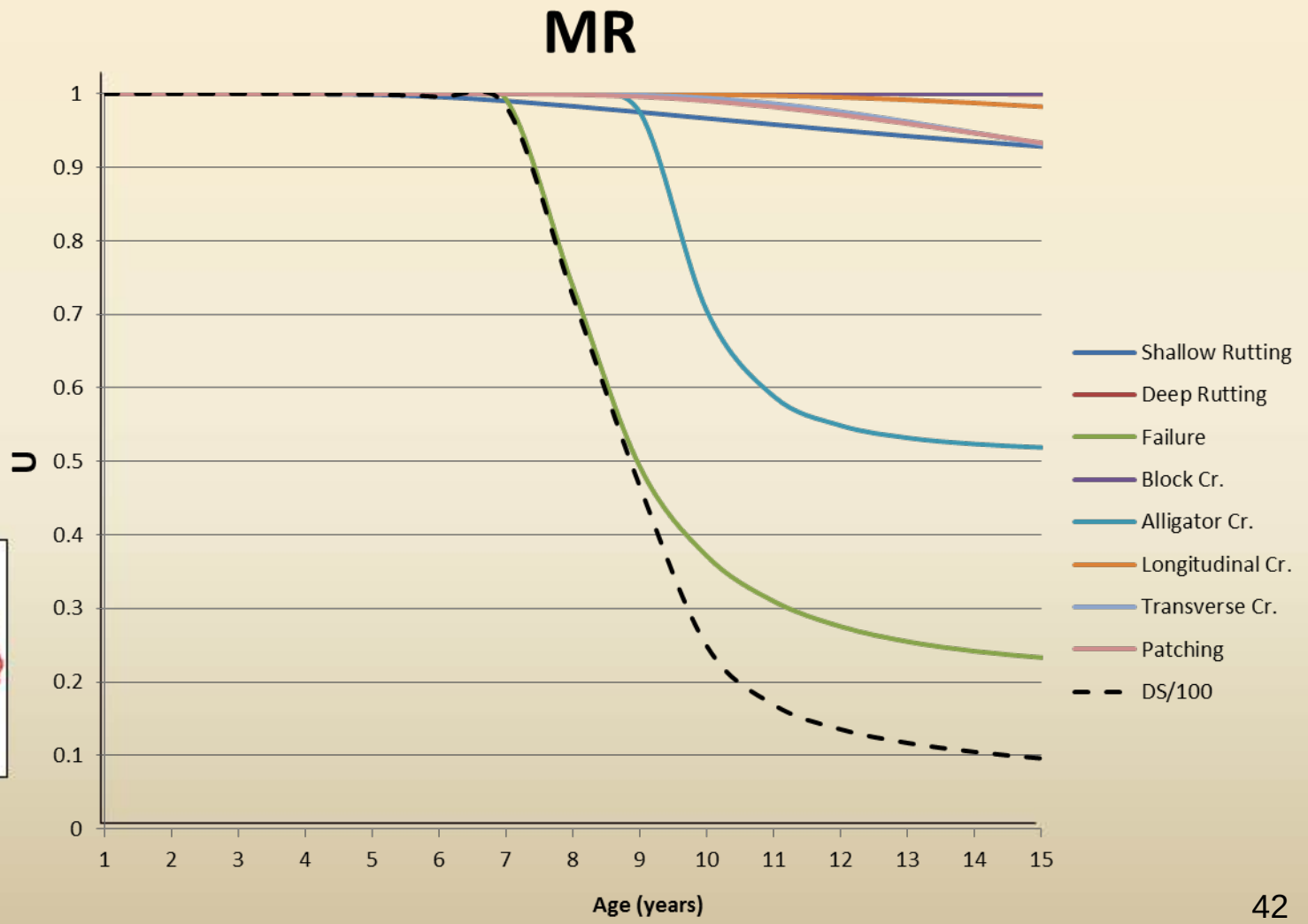


Zone 1, Pvt Family A and High Traffic
(Example — Slide #18)

Districts
PAR
FTW
DAL
TYL
ATL

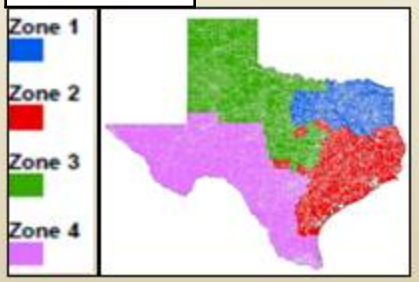


Thick, medium or overlaid ACP

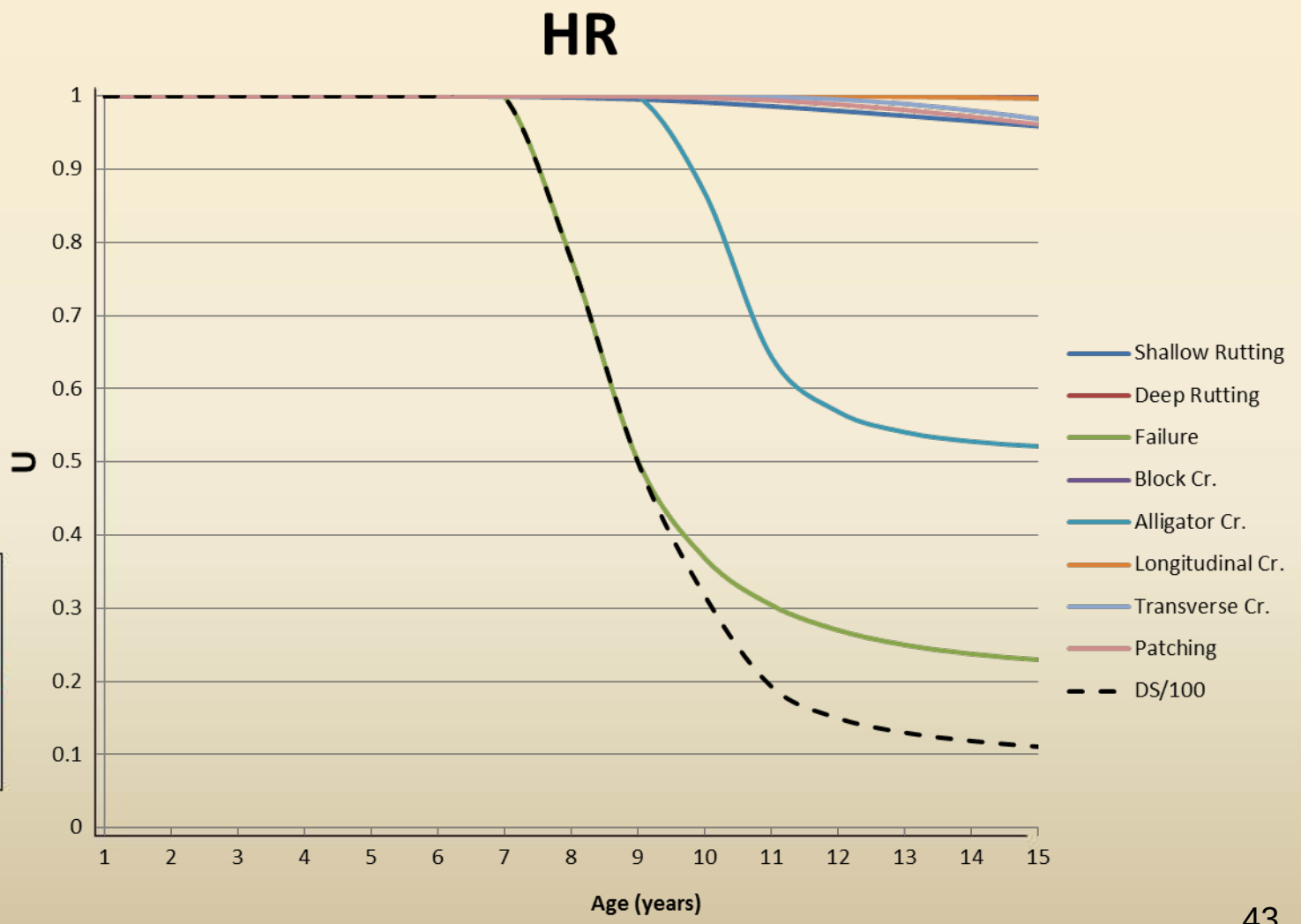


Zone 1, Pvt Family A and High Traffic
(Example — Slide #19)

Districts
PAR
FTW
DAL
TYL
ATL



Thick, medium or overlaid ACP



Thank You!

For Helping Us Improve
PMIS Performance Prediction Models