# 75 YEARS OF WIND EROSION CONTROL

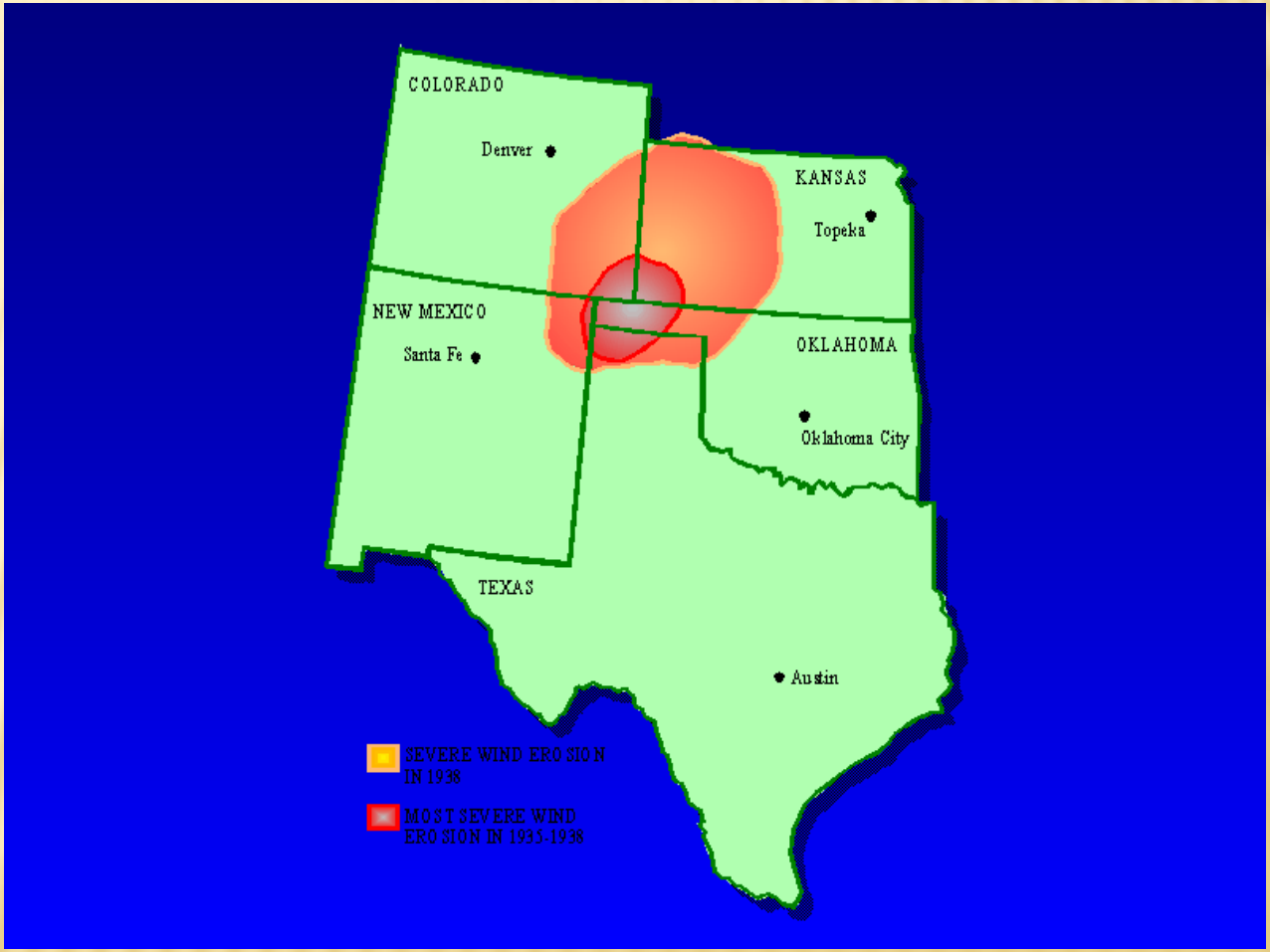
## The History of Wind Erosion Prediction

**Mike Sporcic**, National Wind Erosion Specialist
Central National Technology Support Center
Fort Worth, TX

**Edward L Skidmore**, Soil Scientist (retired)
USDA - Agricultural Research Service
Wind Erosion Research Unit
Manhattan, KS

# TROUBLE IN THE HEARTLAND

We saw the wind erosion problem when we plowed out the short grass prairie without regard to the soil or the climate



# ROOTED IN THE DIRTY THIRTIES

- April 14, 1935 was a dirty day, the “Big Duster”
- Farming in the dry parts of TX, OK, NM, & KS set the nation up for an opportunity to raise concern for wind erosion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# THE DEPRESSION ALSO HELPED

- The National Industrial Recovery Act of 6/16/33 permitted erosion control work.

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# HUGH HAMMOND BENNETT

- **Bennett** worked as a Soil Scientist for the Bureau of Chemistry & Soils.
- He used the April 14, 1933, Sunday erosion event to persuade Congress to act.


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# WIND EROSION MOVED THE BILL THROUGH

- The dust arrived in time to help Bennett get PL46 passed.


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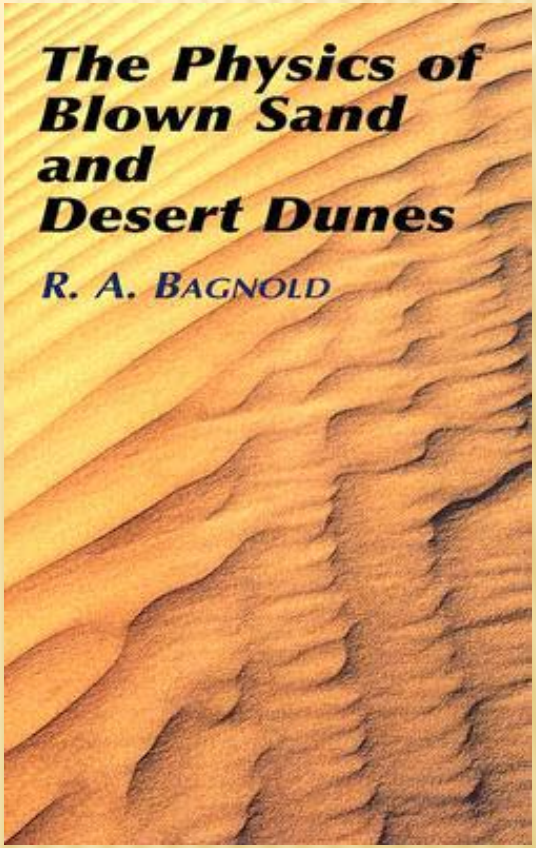
# R. A. BAGNOLD STARTED IT ALL

- Published in 1941, Bagnold stated, “the subject of sand movement lies far more in the realm of physics than of geomorphology.”
- He could be nicknamed the “father of saltation”

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# SCS ESTABLISHES A WIND EROSION PROJECT

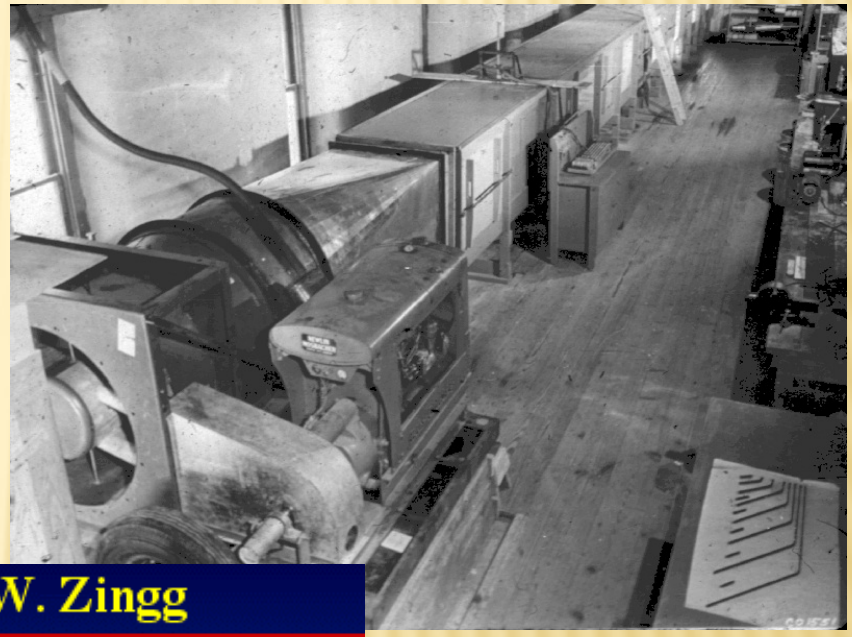
- The Research and Marketing Act of 1946 provided funding for the Wind Erosion Project
- Administered by the Research Division of the Soil Conservation Service
- Established on the campus of Kansas State Agricultural College at Manhattan, KS in 1947


Farm Machinery Hall-ca. 1948 KSAC


Early Field Sampling

# WORK CONTINUED IN THE 40S AND EARLY 50S

- W. S. Chepil, A. W. Znigg, and N. P. Woodruff continued to work with wind tunnels and all aspects of wind erosion.
- Znigg headed the early effort.



A. W. Zingg

W. S. Chepil

NRCS Natural Resources Conservation Service

# CHEPIL'S WORK ON THE WIND EROSION EQUATION

- From 1953 to 1963 **Chepil** headed a team that developed the Wind Erosion Equation (WEQ)
- They established the five key factors dealing with wind erosion:
  - Soil Cloddiness,
  - Ridge Roughness,
  - Field Length,
  - Climate, and
  - Vegetative Material

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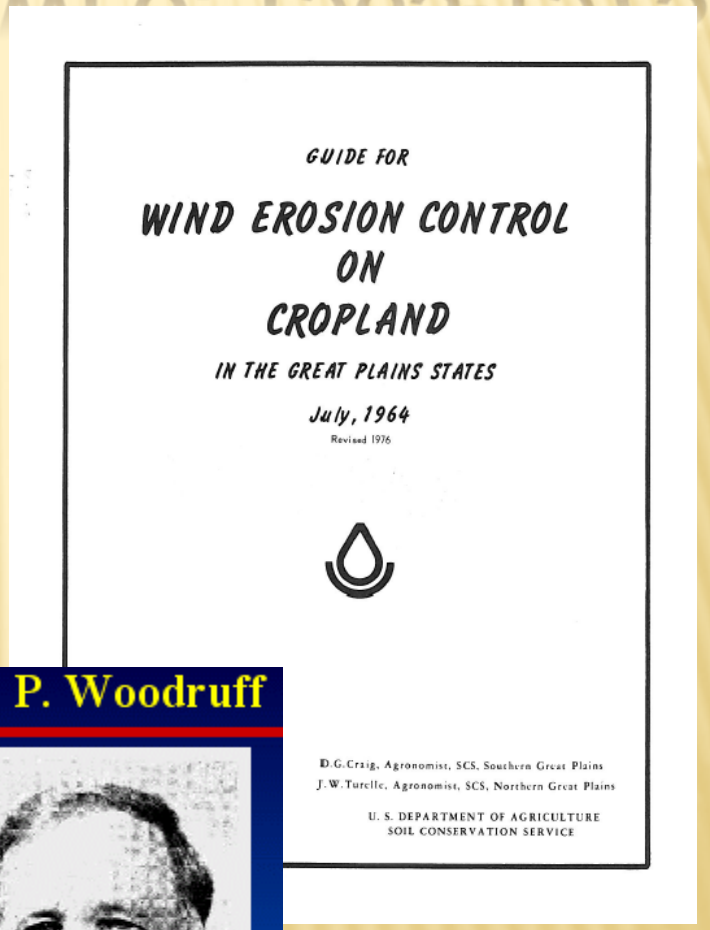
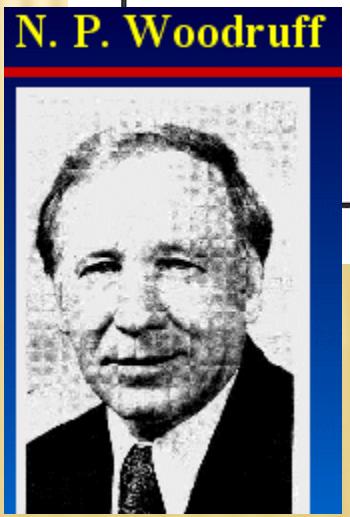
# N. P. WOORUFF FINISHED WEQ, 1963-1975

- **Chepil** died in 1963 before his work was published.
- **Wooruff and Siddoway** published WEQ in 1965.
- The Soil Conservation Service (SCS) began using the model in July of 1964.
- **D.C. Craig and J. W. Turelle** were the SCS agronomists that published the guide.

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# WIND EROSION EQUATION WEQ

**1965**

**E = f ( I, K, C, L, V)**

- **E=soil loss, mass/area/yr**
  - **I = soil erodibility**
  - **K = soil ridge roughness**
  - **C = climatic factor**
  - **L = field length**
  - **V = vegetative factor**

# WEQ - IMPROVEMENTS AND MODIFICATIONS CONT

- Wind erosion calculator, *Skidmore, 1983*
- Wind erosion climatic erosivity, *Skidmore, 1986*
- Wind erosion direction factors…, *Skidmore, 1987*
- Modified EPIC wind erosion model, *Skidmore and Williams, 1991*
- Small-grain equivalent of mixed vegetation…, *Skidmore and Nelson, 1992*

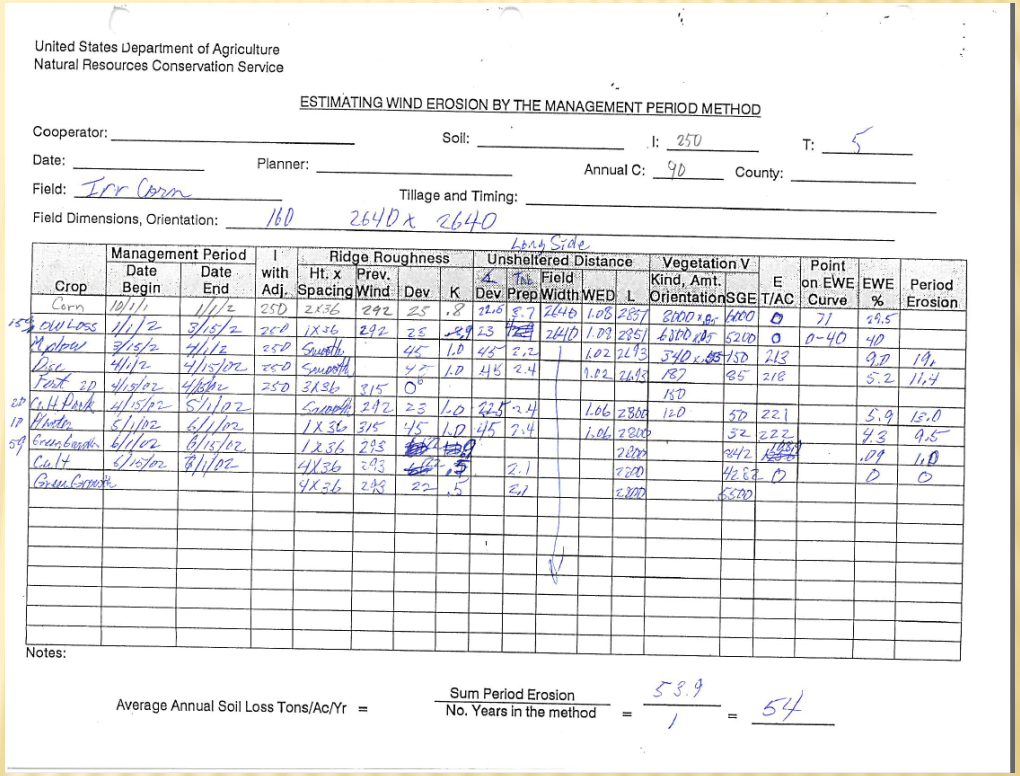
# WEQ – IMPROVEMENTS AND MODIFICATIONS, ARS

- **Assessing Wind Erosion Forces: Directions and…**
  Skidmore, 1965, (monthly magnitudes of the total wind)
- **Wind Erosion Equation: Computer Solution and …**
  Skidmore, Fisher, and Woodruff, 1970 (Step wise solution for WEQ factors)
- **WEROS: A Fortran IV Program to Solve the Wind…**
  Fisher and Skidmore 1970 (how to use the computer version)
- **Range Grasses and There Small-Grain Equiv…**
  Lyles and Allison, 1980

And many more though 1992

# WEQ QUANTIFIED SOIL LOSS

- For the first time after 1965, SCS was able to estimate the loss of soil due to wind
- And develop alternatives to reduce the loss



United States Department of Agriculture
Natural Resources Conservation Service

ESTIMATING WIND EROSION BY THE MANAGEMENT PERIOD METHOD

Cooperator: _____ Soil: _____ I: 250 T: 5

Date: _____ Planner: _____ Annual C: 90 County: _____

Field: Irr Corn Tillage and Timing: _____

Field Dimensions, Orientation: 160 2640 x 2640

| Crop | Management Period Date Begin | Date End | I with Adj. | Ridge Roughness Ht. x Spacing | Prev. Wind | Dev | K | Unsheltered Distance Dev | Prep | Field Width | WED | L | Vegetation V Kind, Amt. Orientation | SGE | E T/AC | Point on EWE Curve | EWE % | Period Erosion |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Corn | 10/1/1 | 11/1/2 | 250 | 2X36 | 292 | 25 | .8 | 22.6 | 8.7 | 2640 | 1.08 | 2857 | 8000 x .85 | 6800 | 0 | 71 | 29.5 | |
| Oat Stubble | 11/1/2 | 3/15/2 | 250 | 1X36 | 292 | 25 | .8 | 23 | 8.7 | 2640 | 1.09 | 2895 | 6800 x .85 | 5200 | 0 | 0-40 | 40 | |
| Alfalfa | 3/15/2 | 4/1/2 | 250 | Smooth | | 45 | 1.0 | 45 | 2.2 | | 1.02 | 2693 | 340 x .85 | 150 | 213 | | 9.0 | 19. |
| Disc | 4/1/2 | 4/15/02 | 250 | Smooth | | 47 | 1.0 | 46 | 2.4 | | 1.02 | 2693 | 187 | 85 | 218 | | 5.2 | 11.4 |
| Fert 2D | 4/15/02 | 4/15/02 | 250 | 3X36 | 315 | 0° | | | | | | | 150 | | | | | |
| C.H Plant | 4/15/02 | 5/1/02 | | Smooth | 292 | 23 | 1.0 | 22.5 | 2.4 | | 1.06 | 2806 | 120 | 50 | 221 | | 5.9 | 12.0 |
| Plant | 5/1/02 | 6/1/02 | | 1X36 | 315 | 45 | 1.0 | 45 | 2.4 | | 1.06 | 2800 | | 32 | 222 | | 4.3 | 9.5 |
| Green Manure | 6/1/02 | 6/15/02 | | 1X36 | 295 | ~~50~~ | | | | | | 2800 | | 242 | ~~1750~~ 1250 | | .09 | 1.0 |
| Cult | 6/15/02 | 8/1/02 | | 4X36 | 293 | ~~55~~ .5 | | | 2.1 | | | 2700 | | 42.2 | 0 | | 0 | 0 |
| Grain Sorghum | | | | 4X36 | 295 | 22 | .5 | | 2.1 | | | 6300 | | 6500 | | | | |

Notes:

Average Annual Soil Loss Tons/Ac/Yr = Sum Period Erosion / No. Years in the method = 53.9 / 1 = 54

- My first one took me 3.5 hours to complete
- And I was never quite sure I made all the interpolations correctly.

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# STRUGGLES FOR IMPROVEMENT TO WEQ

- About 1988, computers made their appearance
- SCS had a DOS version, a FOCS version, a CAMPS version, and finally in 1998 a MS Excel version that actually made it to the field offices

**NRCS - WEQ INPUT WORKSHEET** Version 9.03 11-19-2007

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Producer: | ID | Climate Data Station: | ID, POCATELLO | | | Tract: | | Field: | |
| Planner: | Carrie Smith | Field Width (Ft.): | 2531 | Tillage Direct (NS/EW): | NS | | | Irrigated? (y or n): | Y |
| Crop Rot: | Sbar-Potato-Sbar NT | Field Direction (NS/EW): | NS | Length/Width Ratio: | 1.0 | | | Wind Erodibility Group: | 2 (1-7) |
| Location: | Butte Co, ID | Adjusted Soil "I": | 134 | Site "C" Value: | 20 | | | | |

Average Annual Wind Erosion (t/ac): 1.9 | Yrs in Rotation: 3.0 | Sum Period Erosion: 5.7 (tons/ac)

**Crop and Operation Management Records/Residue Calculations (green and dry)**

| Operation Date (date) | Crop (name) | Operation (name) | No. of Irr./Period (#) | Flat Res. (%) | Yield Adjustment (%) | Yield (units/ac) | Ridge Height (in) | Ridge Spacing (in) | Est Res Retention (fact) | Est. Res. Dry Matter (lb/ac) | Est. Ground Cover (%) | SGe Dry Residue (lb/ac) | Green Dry Matter (lb/ac) | SGe Green Growth (lb/ac) | Random Roughness (in) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1/1/2007 | Barley, spring, high yield | Start Rotation | | 55% | - | - - | 2 | 10 | - | 2000 | 67 | 4688 | 0 | 0 | 0.30 |
| 3/1/2007 | Barley, spring, high yield | Sprayer, 2in x 7in ridge | 1 | 60% | | | 2 | 7 | 0.99 | 1980 | 67 | 4434 | 0 | 0 | 0.25 |
| 4/1/2007 | Barley, spring, high yield | Drill/airseed, DD opener, w/ fert openers N | | 70% | | | 2 | 10 | 0.81 | 1601 | 59 | 3326 | 0 | 0 | 0.30 |
| 4/16/2007 | Spring Grain 15 | Grow | 2 | 70% | | | 2 | 10 | 1.00 | 1601 | | 3318 | 33 | 53 | 0.30 |
| 5/1/2007 | Spring Grain 30 | Grow | 3 | 70% | | | 2 | 10 | 1.00 | 1601 | | 3286 | 175 | 277 | 0.30 |
| 5/16/2007 | Spring Grain 45 | Grow | 4 | 70% | | | 2 | 10 | 1.00 | 1601 | | 3183 | 750 | 1118 | 0.30 |
| 5/31/2007 | Spring Grain 60 | Grow | 4 | 70% | | | 2 | 10 | 1.00 | 1601 | | 3001 | 2400 | 3201 | 0.30 |
| 6/15/2007 | Spring Grain 75 | Grow | 8 | 70% | | | 2 | 10 | 1.00 | 1601 | | 2956 | 3000 | 3887 | 0.30 |
| 8/1/2007 | Barley, spring, high yield | Harvest | | 50% | -50% | 2000 lbs/ac | 2 | 10 | 1.00 | 2000 | 67 | 4901 | 0 | 0 | 0.30 |
| 9/15/2007 | Barley, spring, high yield | Chisel, st. pt. N | | 80% | | | 3 | 30 | 0.37 | 740 | 38 | 1543 | 0 | 0 | 1.50 |
| 4/1/2008 | Barley, spring, high yield | Sprayer, 2in x 7in ridge | 1 | 75% | | | 2 | 7 | 0.99 | 733 | 38 | 1600 | 0 | 0 | 0.40 |
| 4/15/2008 | Barley, spring, high yield | Do all, on beds N | | 100% | | | 6 | 30 | 0.50 | 366 | 22 | 720 | 0 | 0 | 0.40 |
| 5/1/2008 | Potato, early | Planter, DD opener on 8 inch high beds N | | 100% | | | 6 | 30 | 0.97 | 354 | 21 | 701 | 0 | 0 | 0.40 |
| 5/16/2008 | Potato 15 | Grow | 2 | 100% | | | 6 | 30 | 1.00 | 354 | | 691 | 25 | 164 | 0.40 |
| 5/31/2008 | Potato 30 | Grow | 3 | 100% | | | 6 | 30 | 1.00 | 354 | | 666 | 100 | 632 | 0.40 |
| 6/15/2008 | Potato 45 | Grow | 4 | 100% | | | 6 | 30 | 1.00 | 354 | | 532 | 1000 | 5144 | 0.40 |
| 6/30/2008 | Potato 60 | Grow | 5 | 100% | | | 6 | 30 | 1.00 | 354 | | 456 | 2500 | 11172 | 0.40 |
| 7/15/2008 | Potato 75 | Grow | 8 | 100% | | | 6 | 30 | 1.00 | 354 | | 441 | 3000 | 13005 | 0.40 |
| 9/15/2008 | Potato, early | Harvest, root crop | | 100% | | 458 cwt/a | 4 | 40 | 0.23 | 400 | 24 | 157 | 0 | 0 | 0.40 |
| 3/1/2009 | Barley, spring, high yield | Sprayer, 2in x 7in ridge | 1 | 100% | | | 2 | 7 | 0.99 | 396 | 23 | 768 | 0 | 0 | 0.40 |
| 4/1/2009 | Barley, spring, high yield | Drill/airseed, DD opener, w/ fert openers N | | 100% | | | 2 | 10 | 0.81 | 320 | 19 | 647 | 0 | 0 | 0.30 |
| 4/16/2009 | Spring Grain 15 | Grow | 2 | 100% | | | 2 | 10 | 1.00 | 320 | | 635 | 33 | 73 | 0.30 |
| 5/1/2009 | Spring Grain 30 | Grow | 3 | 100% | | | 2 | 10 | 1.00 | 320 | | 592 | 175 | 361 | 0.30 |
| 5/16/2009 | Spring Grain 45 | Grow | 4 | 100% | | | 2 | 10 | 1.00 | 320 | | 505 | 750 | 1318 | 0.30 |
| 5/31/2009 | Spring Grain 60 | Grow | 4 | 100% | | | 2 | 10 | 1.00 | 320 | | 417 | 2400 | 3470 | 0.30 |
| 6/15/2009 | Spring Grain 75 | Grow | 8 | 100% | | | 2 | 10 | 1.00 | 320 | | 400 | 3000 | 4161 | 0.30 |
| 8/1/2009 | Barley, spring, high yield | Harvest | | 50% | -50% | 2000 lbs/ac | 2 | 10 | 1.00 | 2000 | 67 | 4901 | 0 | 0 | 0.30 |
| 12/31/2009 | Barley, spring, high yield | End Rotation | | 55% | | | 2 | 10 | 1.00 | 2000 | 67 | 4688 | 0 | 0 | 0.30 |

Instr | Graphs | Res Wks | Calc | Crop | Oper | Climate | WEG Tab | Cover | Tables

Maybe they shouldn't have given me the that laptop with prelude!

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# DESPITE THE MANY IMPROVEMENTS IN WEQ PROBLEMS PERSISTED WITH THE EMPIRICAL MODEL

- **Climatic factor**

  was unrealistically high in arid climates, too low in humid climates, and did not account for irrigation.

- **Soil erodibility index**

  did not account for temporal variation of aggregate status as influenced by management, weather, etc.

- **Erosion by periods**

  did not account for temporal variation in other model factors like climate, roughness, growing crop, and crop residue.

- **Vegetative cover**

  Small grain equivalent was difficult to communicate to the person in the field.

- **Spatial variability**

  was not recognized

# A BETTER WAY

To better model wind erosion, an effort has been in progress for many years by the USDA – Agricultural Research Service (ARS), to better understand the processes involved and develop a **process-based** Wind Erosion Prediction System (WEPS).

# THE BIRTH OF THE WIND EROSION PREDICTION SYSTEM (WEPS)

- An Organizational meeting was held in October 1985 to develop a replacement model for WEQ.
- There were major issues with WEQ

1. Dryer areas than Garden City, KS seemed to have too high an erosion rate and wetter areas east of the Mississippi River has too low a loss rate.
2. Average monthly wind speeds do not predict average soil loss.
3. There was a need for more information about wind erosion than just rotational average tons/acre/year.

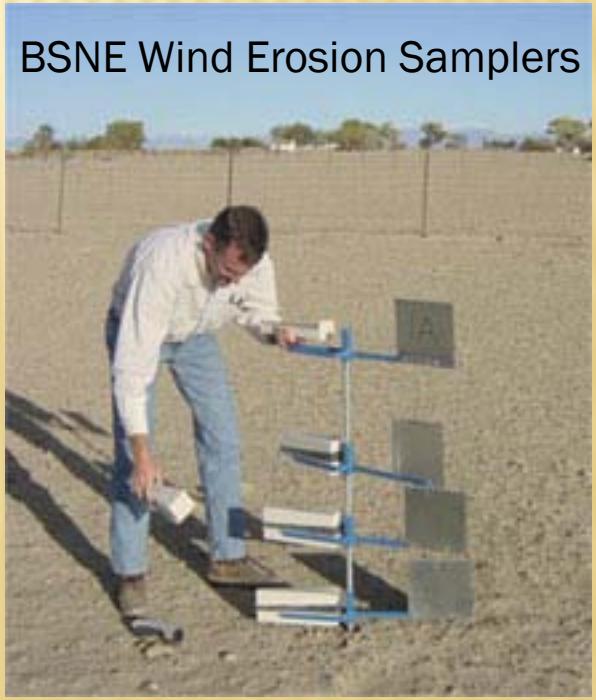
- WEPS was the answer.

# DURING THE 1985 PLANNING MEETING
## CHANGES WERE SUGGESTED

- Dick Amerman, ARS NPL “Develop a physically based model to replace WEQ…”
- Klaus Flack, SCS Chief Scientist was quoted, “We need an erosion prediction, conservation planning tool to document and justify conservation programs, allocate resources… Put some good science into the effort.”
- Rex Johnston, ARS Area Director said “Some of our basic concepts are faulty …lets put some good science into the effort.”

# ADDITIONAL INFORMATION

- Dr. Bill Fryrear, ARS Big Springs, TX made substantial contributions to the work
- Over 3000 samples from 7 states were rotary sieved to established an erodible fraction for each of the soils
- 8 sites were sample during wind events to calibrate the Wind Erosion Prediction System sub-model.

# THE WERE UNIT AND NRCS

- Dr. Ed Skidmore and now Dr. Larry Wagner have headed up the ARS Wind Erosion Research Unit at Manhattan, KS established in 1947.
- The project was under the leadership of SCS until 1953 and then went to ARS.
- They have solved many problems with the Wind Erosion Prediction System (WEPS) since 2005 and given NRCS a very good interface to run the seven sub-models in the software.

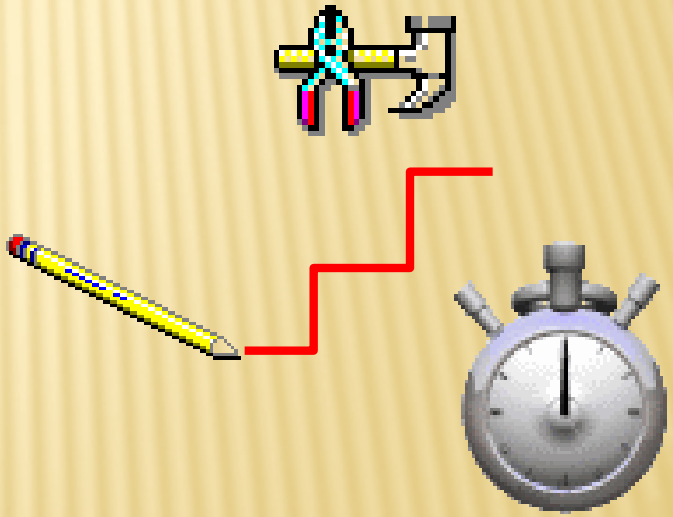
# WEPS ARRIVED

## Wind Erosion Prediction System

**Process-based**

**Daily time-step**

**Wind erosion model**



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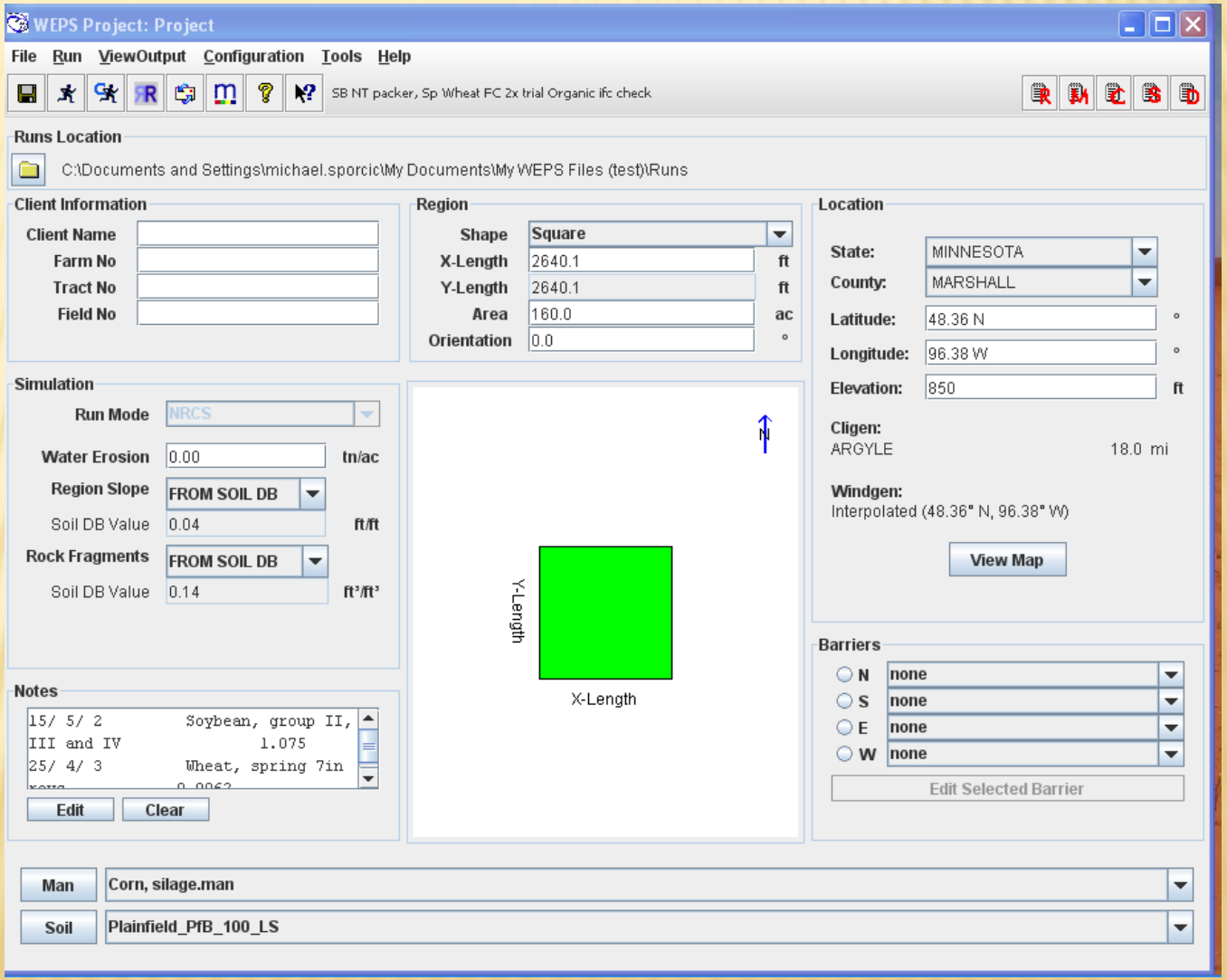
# THE WIND EROSION PREDICTION SYSTEM

- WEPS wind erosion model was handed off to NRCS in 2005.

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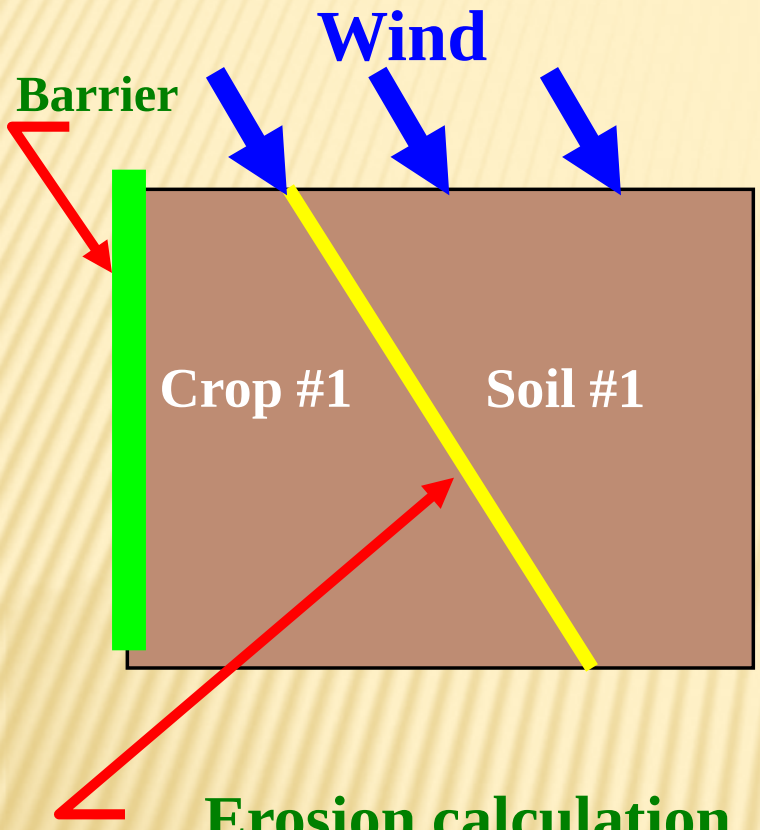
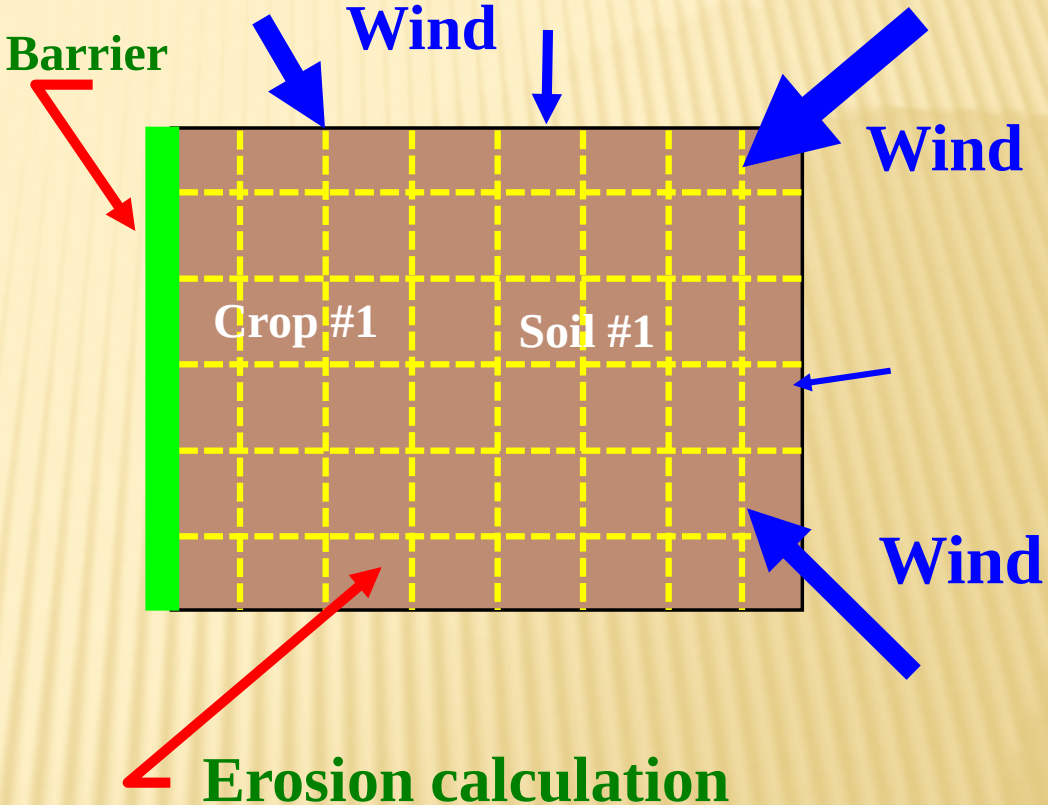
# WEQ COMPARED TO WEPS

## *WEQ*




**Erosion calculation made along a *Linear Transect***

## *WEPS*




**Erosion calculation made for *Grid Areas***

# WEPS GIVES MORE INFORMATION

| | WEPS | WEQ |
|---|---|---|
| Annual soil loss | ✔ | ✔ |
| Period soil loss | ✔ | ✔ |
| Saltation/Creep | ✔ | |
| Suspension | ✔ | |
| PM-10 | ✔ | |
| Surface conditions | ✔ | ✔ Limited |
| Wind energy | ✔ | |
| Boundary loss | ✔ | |

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# PROBLEMS IN WEQ WERE OVERCOME BY WEPS

- Climate Factor *(error in WEQ)*

  - was unrealistically high in arid regions

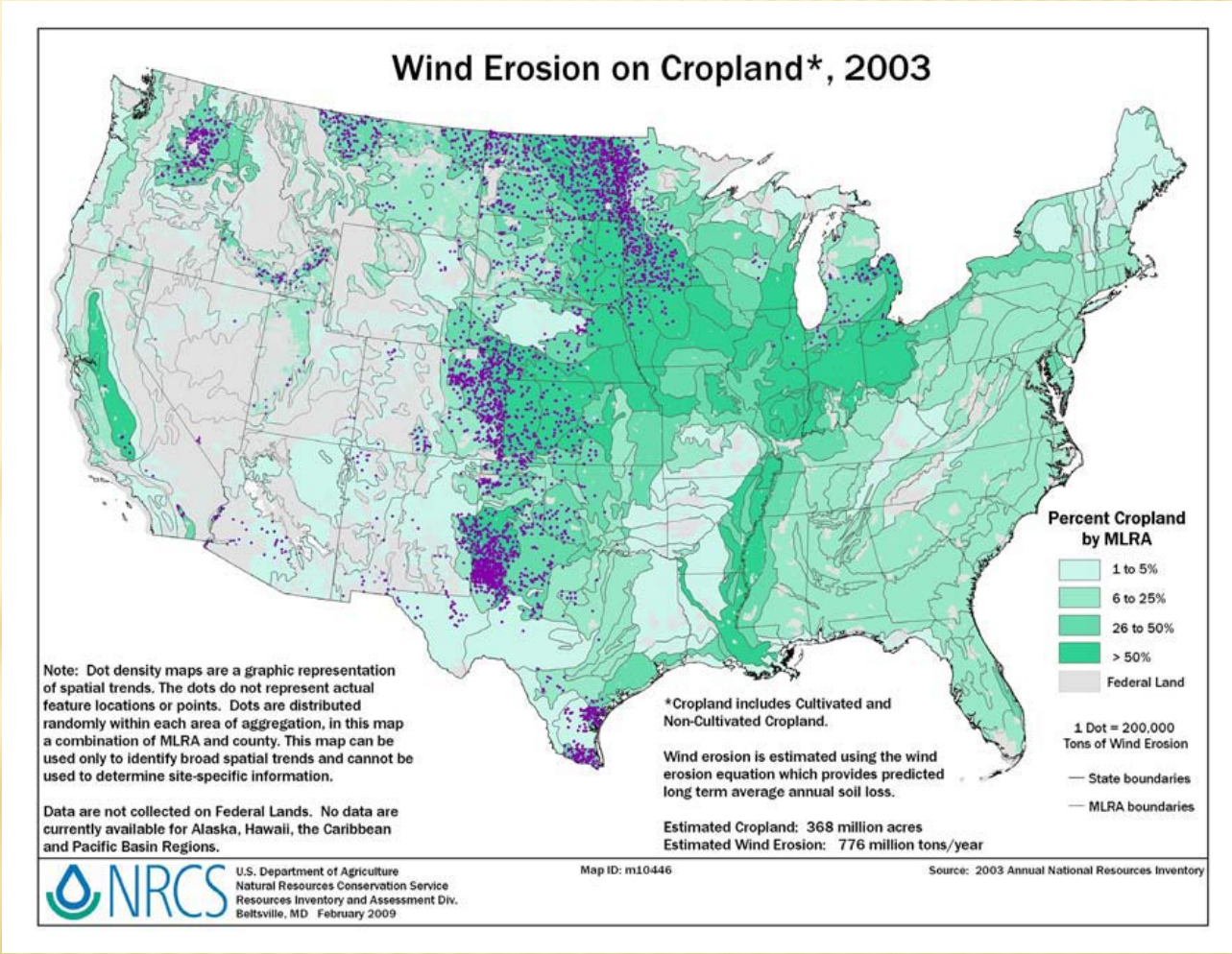
  - was too low in humid climates

  - did not account for irrigation and rainfall on surface conditions

- Soil Erodibility *(error in WEQ)* - did not account for temporal variation of aggregate status.
- Erosion by Periods *(in WEQ)* - did not account for temporal variations factors such as climate, roughness, growing crops, and crop residue.
- Vegetative Cover *(in WEQ)* - Small grain equivalent was difficult to concept to explain and teach.
- Roughness (random and oriented) - is now temporally degraded and accounted for
- Spatial Variability - is now considered

# THE NEED IS STILL THERE

- Each dot ● represents 200,000 t/yr
- The National Resource Inventory shows 776 million t/yr loss to wind erosion




*This map is based on WEQ and does not show correct losses for the eastern US.*

# THERE IS STILL MUCH WORK TO BE DONE



Surgarbeets planted into WW cover in MN



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# NEW WORK-MUCK

- Ted Zobeck, ARS Lubbock,TX and John Tatarko, ARS Manhattan, KS are working on a 3 to 5 year project to better understand wind erosion on Muck soils.

We call this “snirt”
Photo by Jerry Grigar, MI NRCS

# TRENDS THAT ARGUE THE NEED FOR FUTURE APPLICATIONS OF WEPS:

- Widespread use of cellulose for ethanol
- Increased planting of low residue crops
- Expanding urban areas
- Depletion of aquifers i.e. Ogallala
- Climate change
- Work on wind erosion and dust emissions from rangeland. (Southern NM, Tucson, Phoenix, and Southern CA)
- Temporal changes of soil textures and wind removal of residue and snow.

# SUMMARY

- Wind erosion prediction was born out of the dirty 1930s “dust bowl days”
- The Soil Conservation Service worked very hard to get growers to use the best conservation practices.
- Many good scientists have contributed to a much better way to predict wind erosion.
- With the new Wind Erosion Prediction System the Natural Resources Conservation Service can further the work to address the wind erosion that remains.

Strip-till Sugarbeets into Winter Wheat cover crop, Clay Co. MN

Protected Sugarbeets, Clay Co., MN

Winter Wheat strip-cropping

Mulch-Till Sugarbeets into small grain residue

Strip-till Cotton with Winter Wheat cover crop, TX