Utah State University

LECTURE #10

SEDIMENT PROCESSES, PARAMETERS AND CALIBRATION

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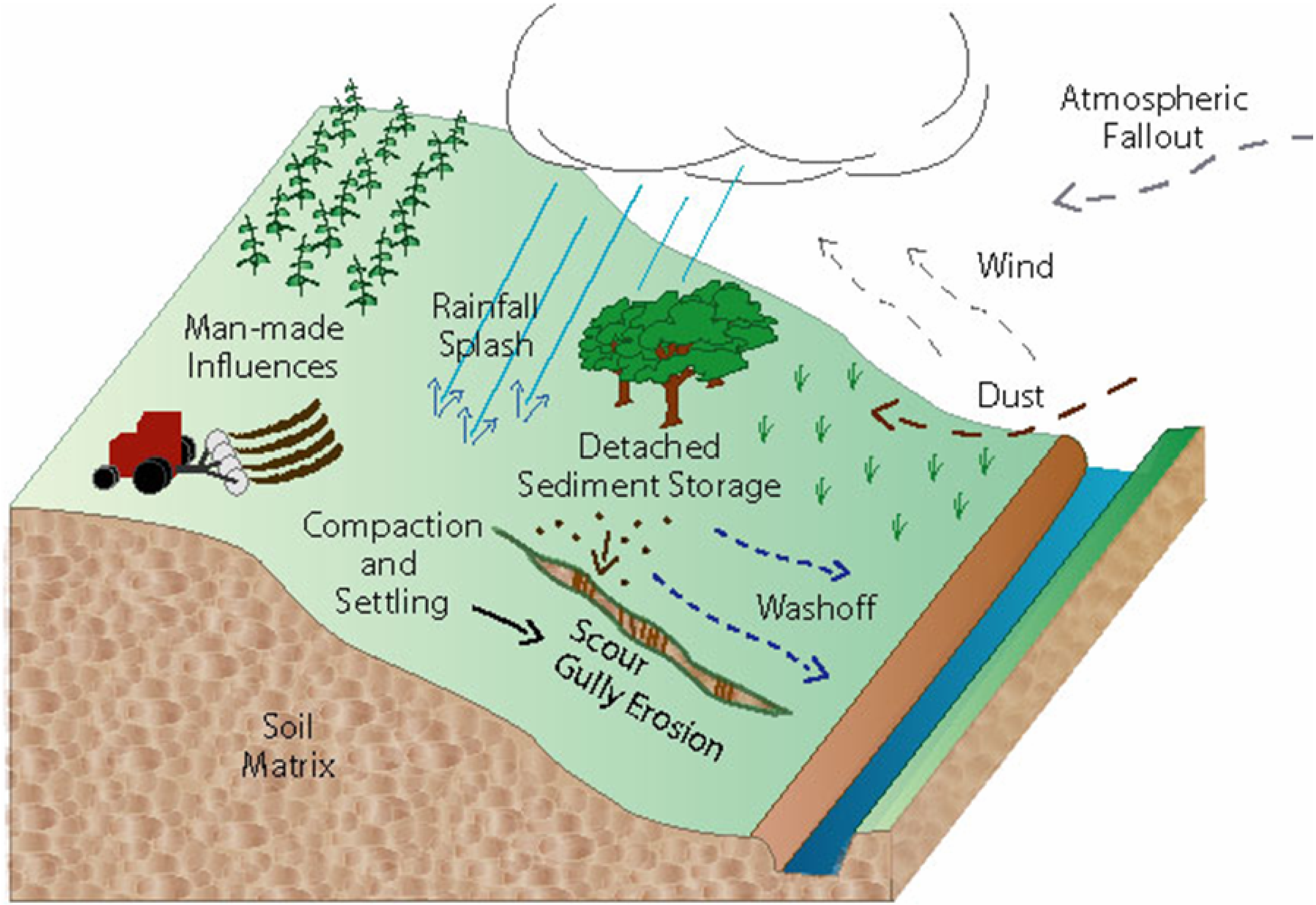
United States Environmental Protection Agency

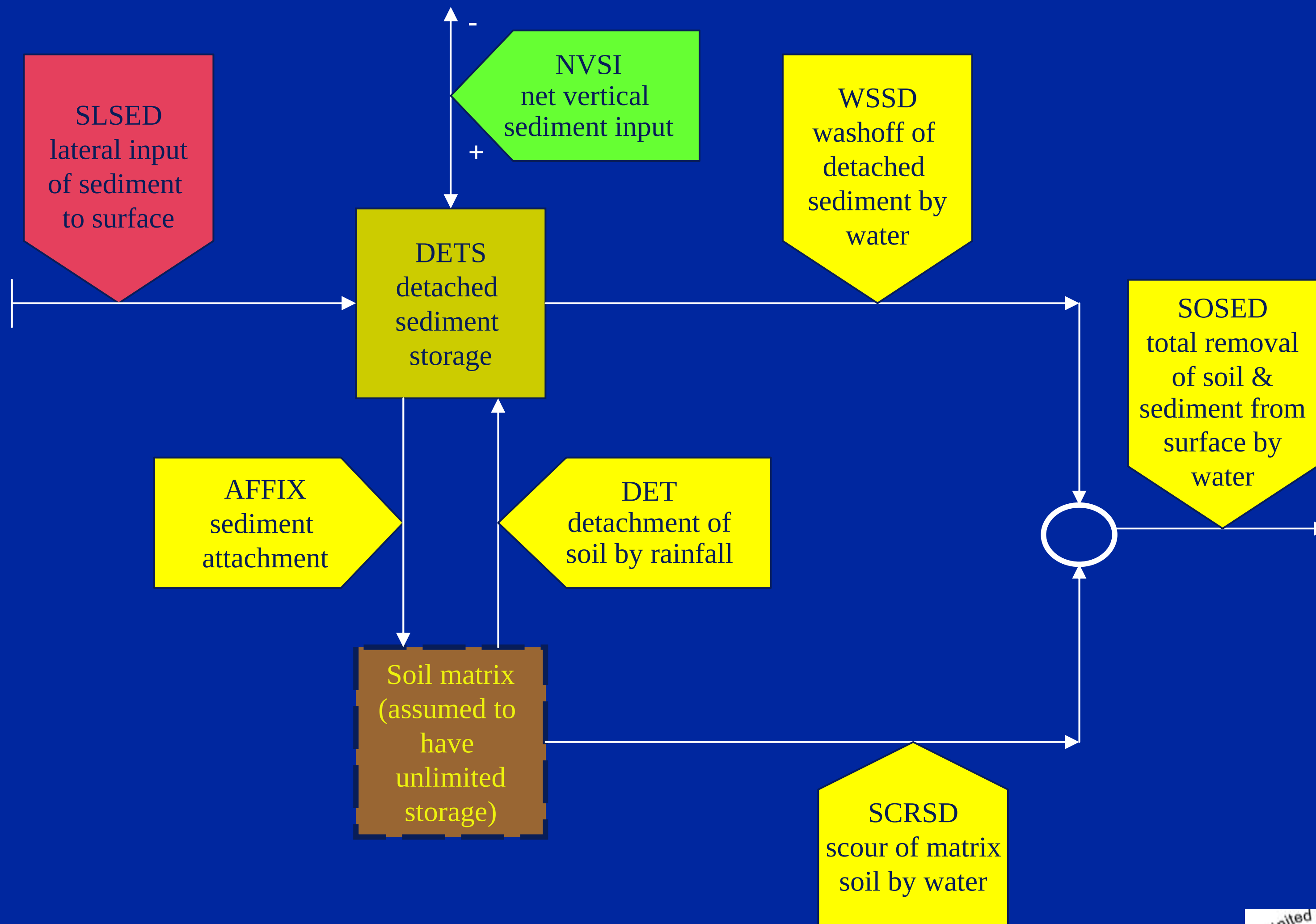
SOIL EROSION PROCESSES



SEDIMENT PROCESSES SIMULATED PERVIOUS AND IMPERVIOUS AREAS

Pervious Areas	Impervious Areas
Accumulation	Accumulation
Detachment	--
Transport	Transport
Scour	

FLOW DIAGRAM FOR SEDMNT MODULE SECTION



SEDIMENT MODULE EQUATIONS - ACCUMULATION/ATTACHMENT

Accumulation/Attachment

DETS(t) = DETS(t-1) * (1.0 - AFFIX) + NVSI

- DETS - Storage of detached sediment (tons/acre)
- AFFIX - Fraction by which DETS decreases each day as a result of soil compaction
- NVSI - Sediment deposition from the atmosphere (lb/acre/day) with a negative value representing removal

SEDIMENT MODULE EQUATIONS - DETACHMENT

Detachment

DET = DELT60*(1.0 - CR)*SMPF*KRER*(RAIN/DELT60)**JRER

DET - Sediment detachment from soil matrix by rainfall (tons\ac\interval)
DELT60 - Number of hours in interval
SMPF - Supporting management practice factor
KRER - Detachment coefficient, dependent on soil properties
RAIN - Rainfall (in/interval)
JRER - Detachment exponent, dependent on soil properties
CR - Fraction of the land covered by snow and other cover

DETS(t) = DETS(t-1) + DET

SEDIMENT MODULE EQUATIONS - TRANSPORT

Transport

STCAP = DELT60*KSER*((SURS + SURO)/DELT60)**JSER

STCAP	- Capacity for removing detached sediment (tons/acre/interval)
KSER	- Coefficient for transport of detached sediment
SURS	- Surface water storage (inches)
SURO	- Surface outflow of water (inch/interval)
JSER	- Exponent for transport of detached sediment

IF STCAP >DETS, (SEDIMENT LIMITING)
WSSD = DETS*SURO/(SURS + SURO)
IF STCAP <DETS (TRANSPORT LIMITING)
WSSD = STCAP*SURO/(SURS + SURO)

WSSD - Washoff of detached sediment (tons/acre/interval)

SEDIMENT MODULE EQUATIONS - SCOUR OF SOIL MATRIX

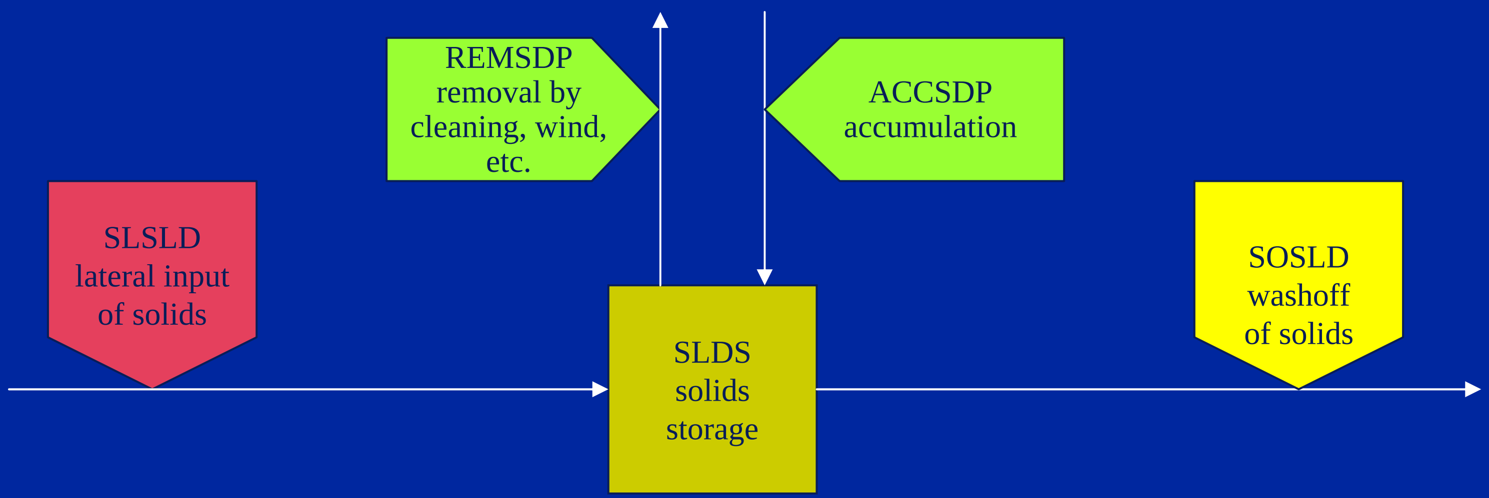
<u>Scour</u>

$$SCRSD = (SURO/(SURS + SURO))*DELT60*KGER*((SURS + SURO)/DELT60)**JGER$$

KGER - Coefficient for scour of the matrix soil

JGER - Exponent for scour of the matrix soil

FLOW DIAGRAM OF SOLIDS MODULE SECTION



SOLIDS MODULE EQUATIONS

Accumulation/Removal

SLDS = ACCSDP + SLDSS*(1.0 - REMSDP)

SLDS	- Solids in storage at end of day (tons/acre)
ACCSDP	- Accumulation rate of the solids storage (tons/acre/day)
SLDSS	- Solids in storage at start of day
REMSDP	- Unit removal rate of solids storage (fraction removed per day)

SOLIDS MODULE EQUATIONS (continued)

Transport/Washoff

STCAP = DELT60*KEIM*((SURS + SURO)/DELT60)**JEIM

KEIM - Coefficient for transport of solids
JEIM - Exponent for transport of solids

IF STCAP >SLDS (SEDIMENT LIMITING)

SOSLD = SLDS*SURO/(SURS + SURO)

IF STCAP <SLDS (TRANSPORT LIMITING)

SOSLD = STCAP*SURO/(SURS + SURO)

Where:
SOSLD - Washoff of solids (tons/acre/interval)

SEDIMENT CALIBRATION - STEPS AND ISSUES

- Sediment Parameter Calibration Process

- Sediment Equilibrium/Balance
  - Pertinent Parameters
  - Fines Deposit
  - Guidelines

- Transport Limiting versus Sediment Limiting

- Parameter Sensitivity
  - Transport Parameters
  - Fines Generation Parameters

FINES DEPOSIT VARIATION

- **Establish Stable Pattern for Each Land Use**

  Cropland - Sharp Increase During Tillage Periods

  Impervious - Cyclical Variation Depending on Weather and Activities

  Rural/Open/Grassland - Relatively Uniform or Slightly Cyclic

- **Guidelines for Adjustment**

	DETS, SLDS		Sediment Washoff		
If	Increasing	and	Too Low	then	Increase Washoff
	Increasing		Too High		Decrease Fines
	Decreasing		Too Low		Increase Fines
	Decreasing		Too High		Decrease Washoff

SEDIMENT EQUILIBRIUM/BALANCE

Pertinent Parameters for Pervious and Impervious Areas

	Fines Availability ⟷	Sediment Washoff
Pervious Areas		
(SEDMNT)	COVER	KSER*
	KRER*	JSER
	AFFIX/NVSI	KGER*
	JRER	JGER
Impervious Areas		
(SOLIDS)	ACCSDP*	KEIM*
	REMSDP	JEIM

* Primary calibration parameters

TRANSPORT LIMITING VS. SEDIMENT LIMITING

Transport Limiting - Transport parameters have primary impact

- Near beginning of major storms
- Periods following tillage or land disturbance
- Storms after an extended dry period, on impervious surfaces

Sediment Limiting - Fines generation and accumulation parameters have major impact

- Small events
- Near the middle/end of major storms
- Near the middle/end of growing season
- Occurs frequently on impervious surfaces

(HSPF allows output displays of STCAP, DETS, and SLDS. See Time Series Catalog in User Manual).

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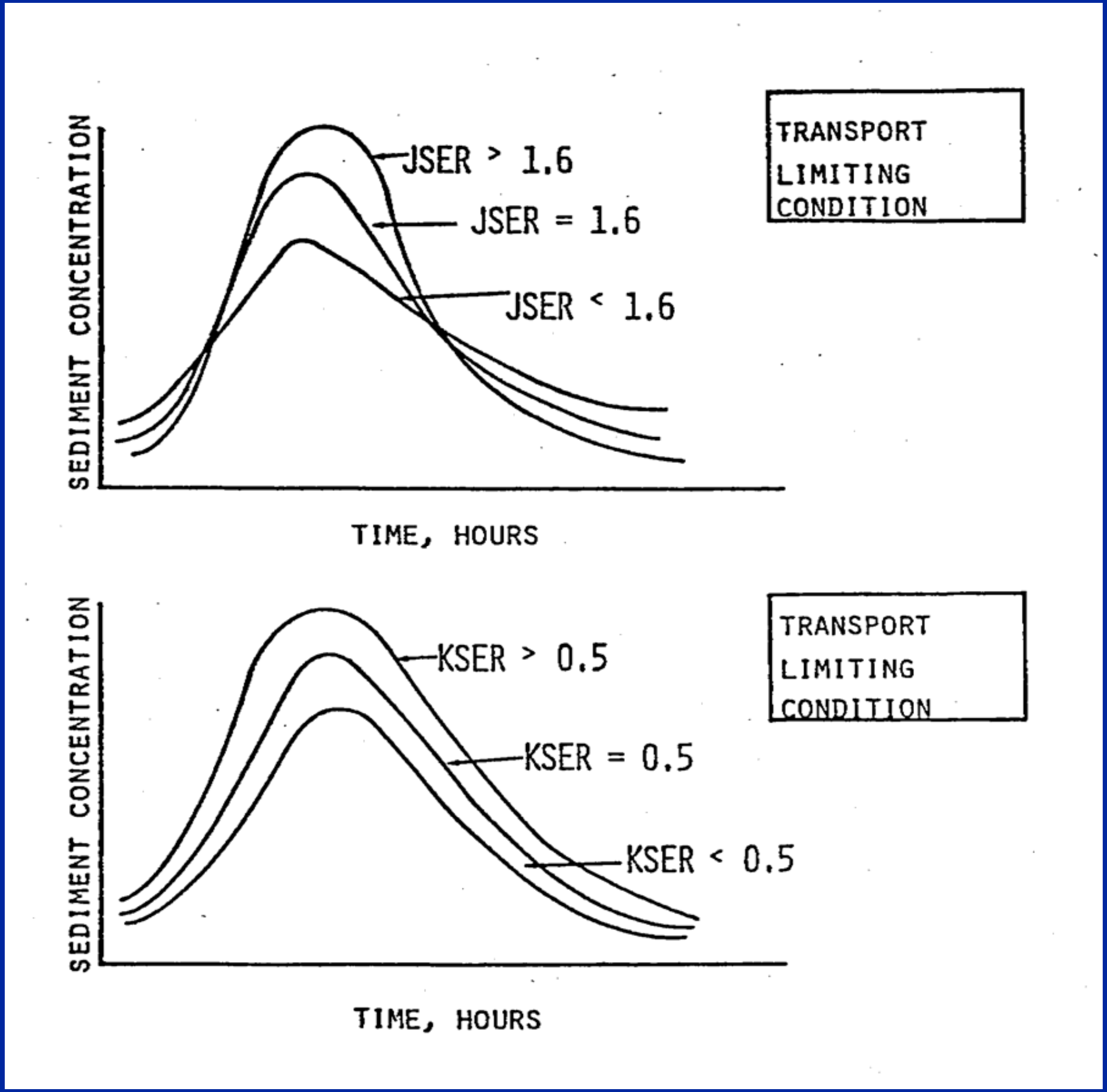
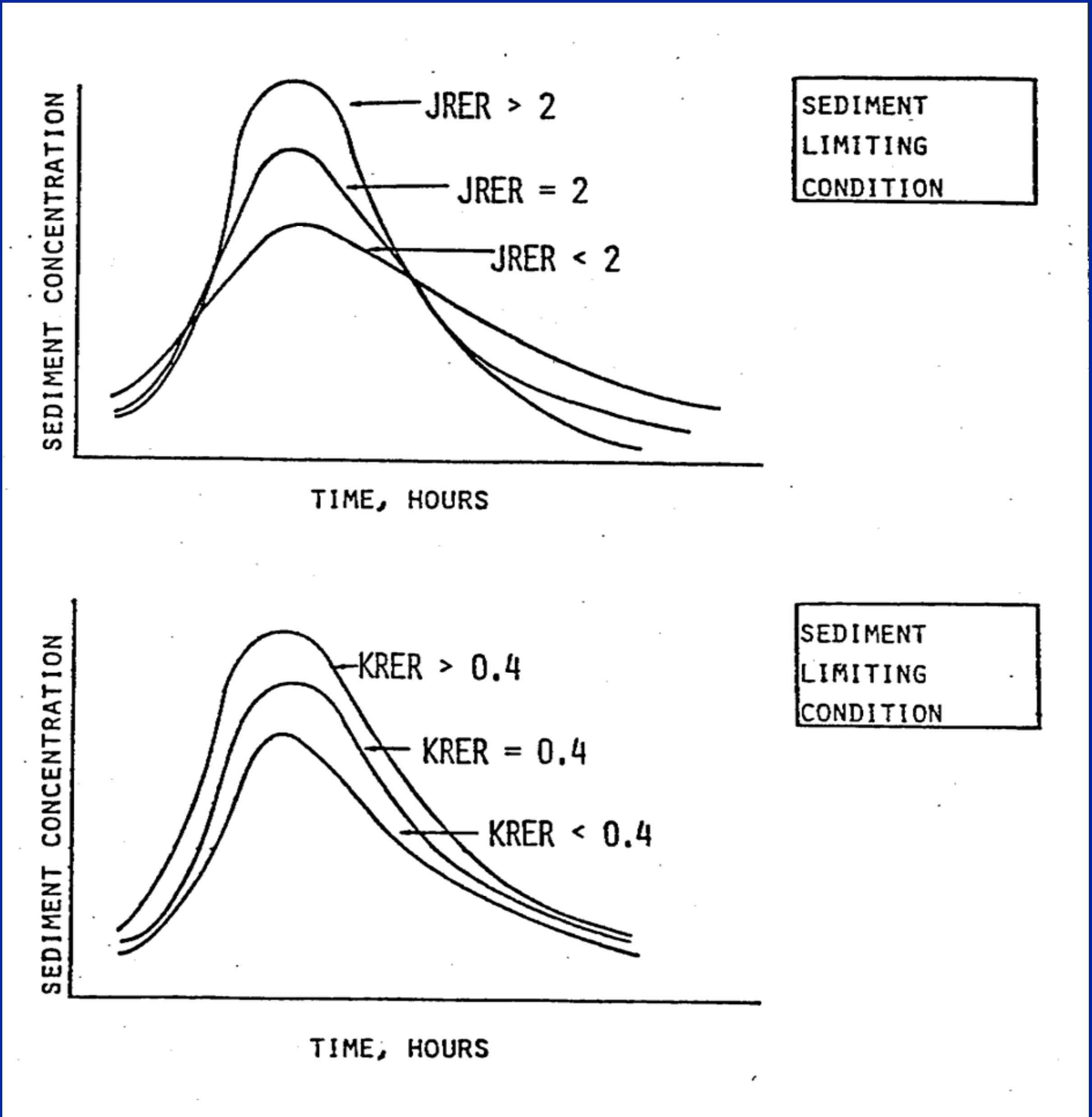
SENSITIVITY/EFFECTS OF TRANSPORT PARAMETERS



SENSITIVITY/EFFECTS OF FINES GENERATION PARAMETERS



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SUMMARY - PRIMARY CONSIDERATIONS IN SEDIMENT CALIBRATION

- Establish Sediment Equilibrium/Balance for Each PERLND, i.e.

  Fines Availability $\longleftrightarrow$ Sediment Washoff

- Be Aware of Transport Limiting Versus Sediment Limiting Conditions

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RANGES OF TYPICAL SEDMNT PARAMETER VALUES

KRER	0.14 - 0.45	Estimate USLE erodibility factor, K
JRER	1.5 - 3.0	
KSER, KEIM	0.1 - 5.0	Key calibration factor
JSER, JEIM	1.5 - 2.5	
KGER	0.01 - 0.5	Gully erosion, not often simulated
JGER	1.0 - 2.0	Gully erosion, not often simulated

COVER

Forest	0.85 - 0.98	
Pasture	0.80 - 0.90	
Conventional Tillage	0.0 - 0.95	Crop dependent
Conservation Tillage	0.30 - 0.95	Crop dependent
Hay	0.65 - 0.95	
Urban	0.80 - 0.95	

DETS (through SPECIAL ACTIONS)

	Tons/ac	tonnes/ha
moldboard plow	3.0 - 5.0	6.7 - 11.2
chisel plow	1.5 - 3.0	3.4 - 6.7
disk/cultivator	2.0 - 4.0	4.5 - 9.0
min. till planter	0.5 - 1.5	1.1 - 3.4

AFFIX	0.03 - 0.10	
NVSI	0.0 - 5.0	lbs/ac/day
	0.0 - 5.6	kgs/ha/day

HSPF SEDMNT PARAMETERS AND TYPICAL/POSSIBLE VALUE RANGES

			RANGE OF VALUES					
NAME	DEFINITION	UNITS	TYPICAL		POSSIBLE		FUNCTION OF ...	COMMENT
			MIN	MAX	MIN	MAX		
PERLND								
SED - PARM2								
SMPF	Management Practice (P) factor from USLE	none	0.0	1.0	0.0	1.0	Land use, Ag practices	Use P factor from USLE
KRER	Coefficient in the soil detachment equation	complex	0.15	0.45	0.05	0.75	Soils	Estimate from soil erodibility factor (K) in USLE
JRER	Exponent in the soil detachment equation	none	1.5	2.5	1.0	3.0	Soils, climate	Usually start with value of 2.0
AFFIX	Daily reduction in detached sediment	per day	0.03	0.10	0.01	0.50	Soils, compaction, ag operations	Reduces fine sediments following tillage
COVER	Fraction land surface protected from rainfall	none	0.0	0.90	0.0	0.98	Vegetal cover, land use	Seasonal/monthly values often used
NVSI	Atmospheric additions to sediment storage	lb/ac-dy	0.0	5.0	0.0	20.0	Deposition, activities, etc.	Can be positive or negative
SED - PARM3								
KSER	Coefficient in the sediment washoff equation	complex	0.5	5.0	0.1	10.0	Soils, surface conditions	Primary sediment **Calibration** parameter
JSER	Exponent in the sediment washoff equation	none	1.5	2.5	1.0	3.0	Soils, surface conditions	Usually use value of about 2.0
KGER	Coefficient in soil matrix scour equation	complex	0.0	0.5	0.0	10.0	Soils, evidence of gullies	**Calibration**, only used if there is evidence of gullies
JGER	Exponent in soil matrix scour equation	none	1.0	3.0	1.0	5.0	Soils, evidence of gullies	Usually use value of about 2.5
IMPLND								
SLD – PARM2								
KEIM	Coefficient in the solids washoff equation	complex	0.5	5.0	0.1	10.0	Surface conditions, solids charac.	Primary solids **Calibration** parameter
JEIM	Exponent in the solids washoff equation	none	1.0	2.0	1.0	3.0	Surface conditions, solids charac.	Usually use value of about 1.8
ACCSDP	Solids accumulation rate on the land surface	lb/ac-dy	0.0	2.0	0.0	30.0	Land use, traffic, human activities	**Calibration**, primary source of solids from impervious areas
REMSDP	Fraction of solids removed per day	per day	0.03	0.2	0.01	1.0	Street sweeping, wind, traffic	Usually start with value of about 0.05, and calibrate

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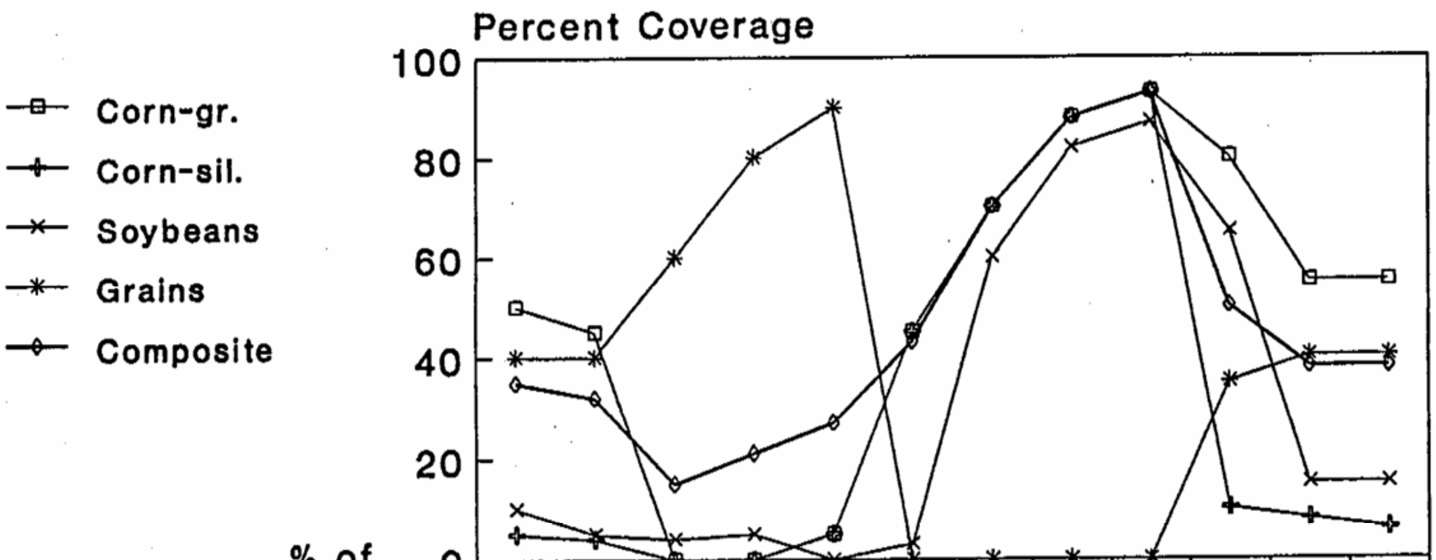
COVER PATTERN FOR CONVENTIONAL TILLAGE

Percent Coverage - Conventional Tillage
Juniata Segment 100



	% of Cropland	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Corn-gr.	46.3	50	45	0	0	5	45	70	88	93	80	55	55
Corn-sil.	25.3	5	4	0	0	5	45	70	88	93	10	8	6
Soybeans	2.8	10	5	4	5	0	3	60	82	87	65	15	15
Grains	25.6	40	40	60	80	90	0	0	0	0	35	40	40
Composite	100.0	35	32	15	21	27	43	70	88	93	50	38	38

Time (Months)

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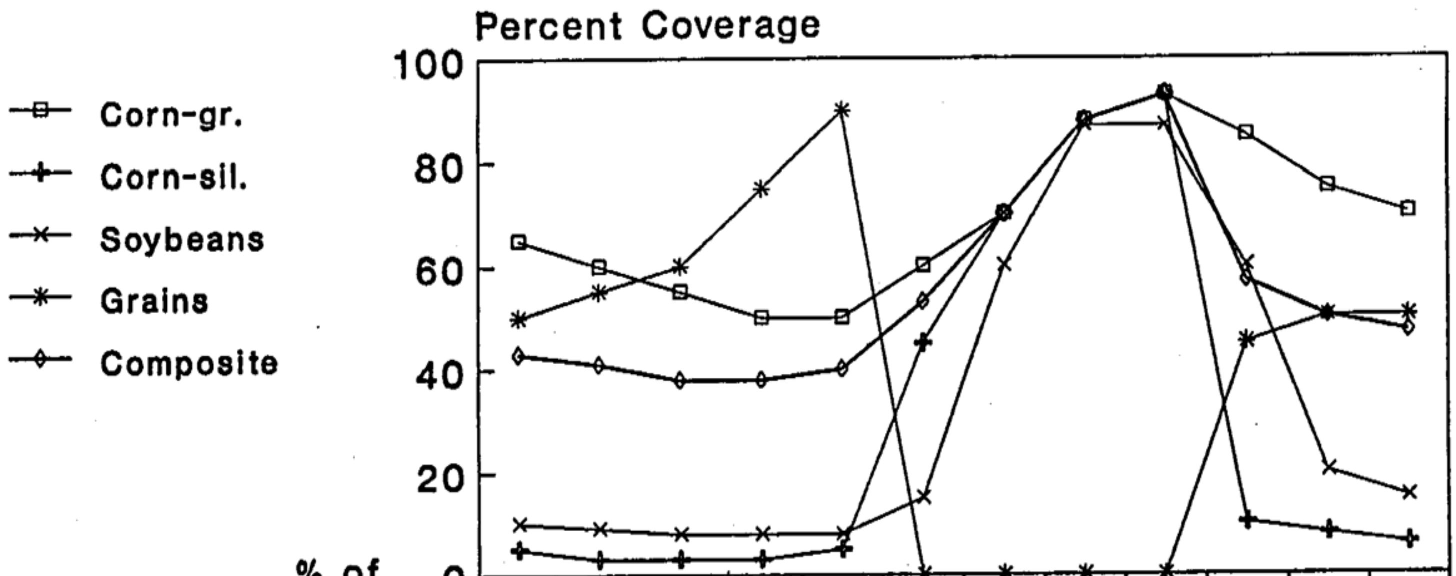
COVER PATTERN FOR CONSERVATION TILLAGE

Percent Coverage - Conservation Tillage
Juniata Segment 100



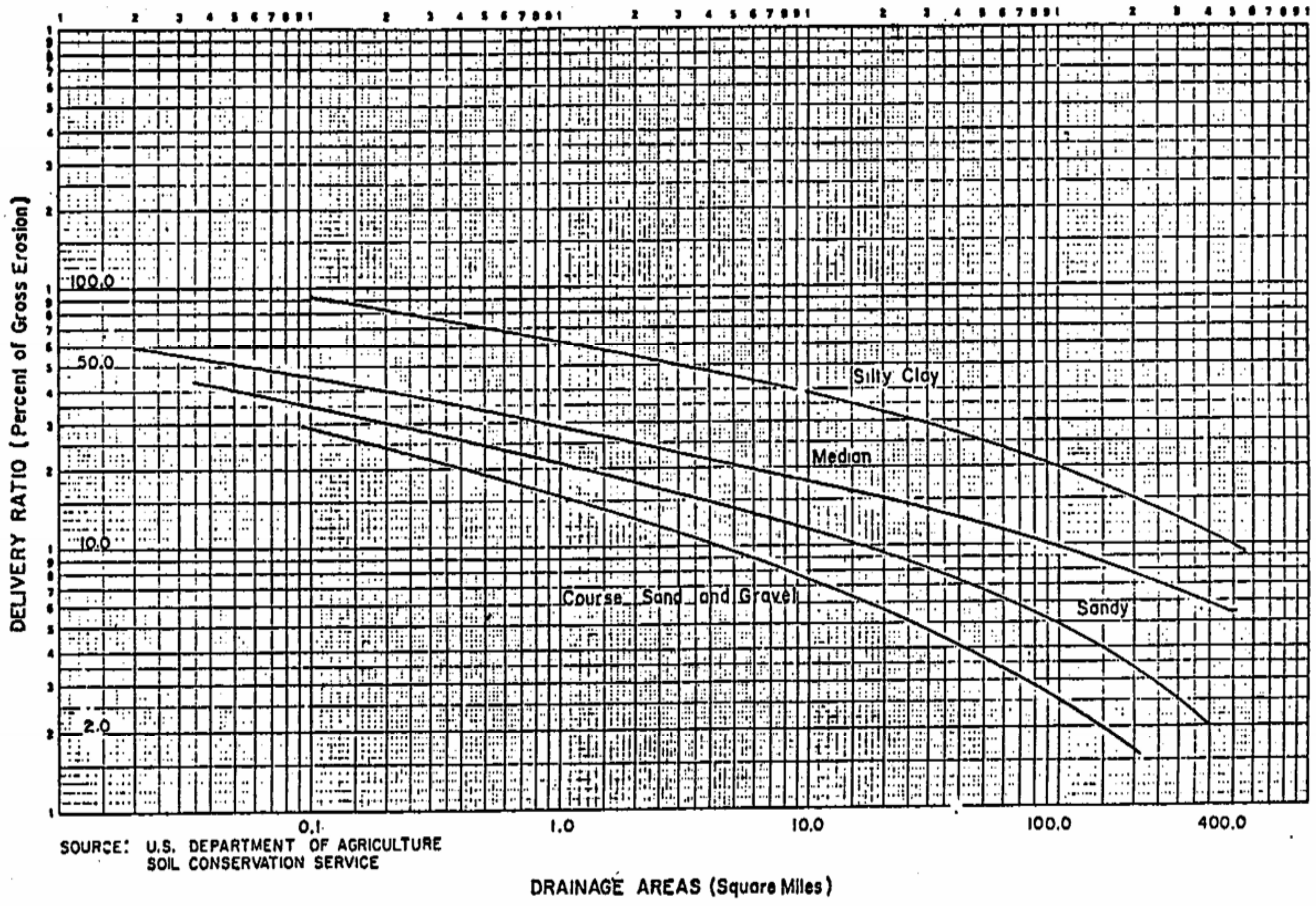
	% of Cropland	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Corn-gr.	54.4	65	60	55	50	50	60	70	88	93	85	75	70
Corn-sil.	29.8	5	3	3	3	5	45	70	88	93	10	8	6
Soybeans	3.5	10	9	8	8	8	15	60	87	87	60	20	15
Grains	12.2	50	55	60	75	90	0	0	0	0	45	50	50
Composite	100.0	43	41	38	38	40	53	70	88	93	57	50	47

Time (Months)

TYPICAL RANGES OF EXPECTED EROSION RATES

	Tons/ac/yr	Tonnes/ha/yr
Forest	0.05 - 0.4	0.1 - 0.9
Pasture	0.3 - 1.5	0.7 - 3.4
Conventional Tillage	1.0 - 7.0	2.2 - 15.7 (crop dependent)
Conservation Tillage	0.5 - 4.0	1.1 - 9.0 (crop dependent)
Hay	0.3 - 1.8	0.7 - 4.0
Urban	0.2 - 1.0	0.4 - 2.2
Highly Erodible Land	> ~ 15.0	> ~ 33.6

SEDIMENT DELIVERY RATIO VERSUS SIZE OF DRAINAGE AREA



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