Wind Erosion Control on Irrigated Columbia Basin Land

A Handbook of Practices

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WIND EROSION CONTROL

ON IRRIGATED COLUMBIA BASIN LAND

A HANDBOOK OF PRACTICES

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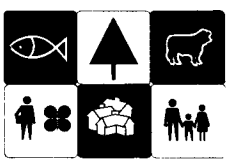

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FOREWORD

In June, 1972, the Agricultural Research Service, United States Department of Agriculture, in cooperation with the Kansas Agricultural Experiment Station, published USDA Agr. Inf. Bull. 354, "How to Control Wind Erosion". In that publication, principles of wind erosion were discussed and recommendations were made for controlling soil removal by wind under a variety of soil conditions, but not for the nearly pure sands found in the lower Columbia Basin in Oregon. This publication extends the recommendations to these unusually erosive soils which are similar to coastal dune sands and presents details of management practices useful for applying the recommendations to the crops, weather, and soils of the lower Columbia Basin.

Situations will arise which may require deviations from the recommendations presented herein. These deviations can result from a farmer's knowledge of wind erosion principles and experience with wind erosion conditions. A handbook cannot address all combinations of developments, events, and circumstances without being lengthy. Therefore, recommendations in this handbook are guidelines for profitable conservation farming of sandy soils and are subject to revision as new technology develops. The monetary cost of erosion control to farms is recognized and every effort was made to reduce costs to a minimum and still maintain reasonable probability of preventing excessive wind erosion damage to fields and their environments.

Little information is available by which the probability of success or failure can be quantified. More research is needed so soil erosion by wind under different combinations of soil, water, crop management, and wind conditions can be described and controlled.

This publication is a handbook. After a brief introductory statement, a series of general recommendations are listed. Then specific recommendations for several important crops are given. Finally a series of appendices of explanatory statements follow.

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WIND EROSION CONTROL

ON IRRIGATED COLUMBIA BASIN LAND:

A HANDBOOK OF PRACTICES

Irrigation development in Morrow and Umatilla Counties is occurring on arid lands which are inherently susceptible to wind erosion. This erosion results in losses of crops and soils and deterioration of the environment. Several agronomic and social consequences must be considered.

The agronomic problems are complex. A severely eroded field will have reduced soil depth and in shallow soil areas the underlying bedrock may be exposed. Loss of fine particles and humus will have occurred leaving coarse, drouthy particles. Coarse particles are deposited in drifts, hummocks and dunes in the field and adjacent downwind areas which may include neighboring farms. Growing crops are sandblasted, blown out, or buried. Expensive fertilizers and pesticides may be blown away. Buildings and farm machinery can be damaged.

Soil erosion by wind pollutes the air with dust and causes environmental quality problems. Dust affects the public in many ways. Soil particles and humus may cause respiratory problems in people and animals. Agricultural chemicals applied to the soil for weed and insect control may be removed from the intended site. Dust clouds over highways and roads are hazards to safe driving while wind blown sand deposits close roadways to traffic necessitating expensive cleanout operations. Homes, businesses, and industry suffer from dust. Drifting sands fill irrigation ditches, canals, and reservoirs and pollutants are added to the rivers and streams. Overall, land values and orderly development of lands are jeopardized by excessive erosion.

Harmonious and balanced resource development and use must provide investment incentives and opportunities for enterprising individuals. Useful advice must include economical considerations for the farmer. There must be a level of wind erosion control which is profitable for the skillful manager. However, this level of contol will not be effective under extreme conditions.

This handbook proposes simple measures which will control soil erosion by wind. They are not absolute solutions; none are known. But several practices can conserve soil resources and provide satisfactory cleanliness of air, water, and land within the framework of profitable farming.

CONTROL PRACTICES

Recommendations are made with the following considerations in mind:

(1) Soil and water management programs in areas where erosion hazards are severe must be designed to fit the soil, climate, and crop conditions. Wind erosion is a constant concern in areas such as the Columbia Basin. Conservation management *must* be part of the long range plans for any farm. The Soil Conservation Service, USDA, upon request, will help farmers and land-owners develop conservation farming plans

based on the best currently available erosion control guidelines. The Soil Conservation Service can evaluate land with respect to its suitability for development and can suggest whether and how development should occur based on wind erosion control guidelines.

(2) In the lower Columbia Basin of north central Oregon, soils range from coarse sands which do not form durable clods to silt loams which can be cloddy if properly tilled. This difference in clod formation affects the kind of wind erosion control practices that are most appropriate.

(3) Principal weather factors affecting wind erosion are aridity and the season, direction, velocity, and frequency of winds. In the lower Columbia Basin, winds are predominately westerly, and frequently reach soil eroding velocities, especially during winter and spring. However, strong winds may occur in any season of the year.

(4) Existing residues, whether or not an area has been previously cropped, can influence the erosion control practices needed.

(5) The climate and growing season are suitable for a wide variety of crops. Only a few crops currently important in the area are used to illustrate wind erosion management practices. Several management alternatives can be fitted into conservation plans as shown by some examples given in table D-1, page 24 of the appendix.

(6) Considerable hazard and damage can result from erosion on non-cropped land. Therefore, several recommendations are included for reduction of hazard on special use areas.

General Recommendations

1. PLANNING:

Long range plans should include rotations, trees, shrubs, or perennial tall grass *windbreaks*. *Plan crop rotations* to provide quick or permanent covering of the soil (see chart D-1, page 24). Install and maintain *permanent solid irrigation* systems along very vulnerable portions of fence lines, roadways, and windbreaks.

There is place to place variation in prevailing wind direction within the area these recommendations are intended to serve. Therefore, it is necessary for each user to determine the prevailing wind direction at his site. In general the winds are westerly. At most locations, winds from directions south of west occur more frequently than from north of west.

2. PREPAREDNESS:

Always be prepared for strong winds. They can arise at *any time*, even though they are more frequent during the November-April period. Keep *crops or crop residues* on the land as much as possible.

Plan *long range cropping patterns* to provide quick, adequate crop cover on the soil (See appendix D, page 20).

Have *mulch* materials (straw, residues, unpulverized manure, wood wastes, sludges, etc.) and mulch handling machinery available for *emergency treatment* of blowouts.

Ridging equipment should also be available but this control is very temporary on sandy soils.

Discipline workers, visitors, and others to avoid unnecessary traffic in prepared fields. The slightest surface disturbance can frequently initiate soil movement.

Plant *windbreaks* as soon as possible.

3. IRRIGATION CAPABILITY

Have the *irrigation system functional before* land clearing, smoothing, or any land preparation begins. Do *not depend on irrigation alone* for wind erosion control. Irrigation provides cover and wetness, but alone will not prevent wind erosion unless adequate equipment is available to maintain moist surfaces over entire fields. This *cannot* be done with center pivots or the usual irrigation systems.

Wet the soil to field capacity prior to tillage. Tilling wet soils forms a *cloddy condition* which is useful, and helps in binding soil particles to plant residues.[1/] A sufficiently cloddy condition is virtually impossible to achieve and maintain in coarse sandy soils.

[1/] While the recommendation is contrary to good soil management because soil compaction can be a serious problem, it is important in this case because of the contribution cloddiness makes to wind erosion control.

4. TILLAGE:

Do *minimal land preparation.* Minimize shaping and grading. Confine to area to be cropped. On new land, avoid starting prior to March 15 and plan to have land under cover crop by September 15 unless special protection such as a hauled in mulch is provided.

Leave irregular shaped, non-farmed areas *vegetated.* Keep *roadways* at a minimum and gravel or otherwise cover permanent roads as soon as possible. Restrict traffic to that necessary for management.

Reduce tillage at every opportunity to do so. Replace tillage with herbicides whenever it is practical. Irrigate prior to tillage and *till while wet* to form clods. *Strip till* for fine seed bed where necessary for such crops as sugar beets. Finely tilled seed rows should be *narrow* (4-6 inches) with cloddy, residue-laden or cover cropped inter-row areas.

Subsurface tillage with chisels, shanks, or sweeps is helpful. Till and form beds in a *cross wind* direction. Keep *clods* and *residues* on the *surface* as much as possible.

Confine all field operations (tillage, smoothing, bedding, planting, cultivating, digging, etc.) to the cross wind direction to the maximum extent possible. Cross tillage, where necessary, can be performed on the diagonal rather than aligned with the prevailing wind direction.

5. CROPPING:

Adopt cropping practices for *year-round* cover to the maximum extent feasible. The following are examples which can be fitted into rotations and provide winter season ground cover (see chart D-1, page 21):

1. Irrigated pastures, short-term and long term
2. Irrigated hay
3. Double cropping leaving stubble cover
4. Biennial or perennial seed crops
5. Cereal grains
6. Cereal or alfalfa for green chop
7. Cereal silage or hay-lage
8. Vineyards or orchards

Annual crops compatible in a rotation with winter cover crops include potatoes, peas, corn, dry beans, greenbeans, soybeans, safflower, other oil seeds, melons, seed crops, sugar beets, turnips, and others.

Crops seeded *April 15 to September 20* have the best chance of establishing a protective ground cover. For earlier or later plantings, other erosion control practices, such as strip-planting or mulches should be used.

Adopt *strip cropping;* different planting dates of the same crop, or the mixing of *compatible crops* in cross wind strips in the same field wherever feasible. Use strip cropping on new or previously cropped land, *especially sandy land.* Corn or sorghum is compatible with many crops.

6. RESIDUES:

Firm wet *trashy* soils with a ring roller to provide wind resistance and favorable seedbeds.

Use herbicides, followed by no till planting, with sweeps, or chisels to leave residues *on the soil surface* where their effectiveness is maximum. Residues reinforce the cloddy condition of loams and silt loams, and substitute for clods on sandy soils. Residues on the soil surface *will last longer* than if incorporated into the soil. *Supplement* with manure, straw, or other hauled-in material if residue cover is inadequate. Scatter residues and *"tuck in"* or anchor with a disk.

Specific Recommendations For Protective Cropping Practices

NEW CROPLAND:

Ideally, new cropland should be broken out in mid-summer and planted before September 15 to winter cover crops, small grains, or more permanent cover such as hay or pasture. *Row crops* are *not well adapted* as first crops. Row crops should follow winter cover or other crops which leave more residues.

FALL SMALL GRAINS planted after August 15 and *before September 15* provide excellent winter cover. For earlier planting use sudangrass, grain sorghum, corn, or other warm season crop. *Wheat* can be *planted into 6-10 inch stubble* of the warm season crop after harvest of silage, haylage, or green chop.

HAY OR PASTURE should be seeded into a previously established nurse crop during the August 1 to September 15 period. Select the nurse crop according to suitability with respect to planting date and capability to produce quick cover. Excessive cover crop or weed growth can be controlled with selective herbicides.

POTATOES as a first crop on newly developed land are vulnerable to wind erosion and should be limited to fields requiring only minimal preparation. Even then, *special precautions* such as the following are required.

Spray native vegetation with herbicide. After kill, irrigate and *work wet* with sweeps to leave a maximum of *clods and trash* on the surface. Fertilize and plant crosswind. Irrigate after planting to settle the soil. Have straw or other material available to use on blow areas.

Avoid *early plantings* of potatoes on new land having a minimum of residues unless straw, manure, or other suitable mulching material is spread on the land.

DEVELOPED CROPLAND:

HAY AND PASTURE should be planted with *no tillage*. Required land leveling should be accomplished before seeding the previous crop. Recommended planting dates for the commonly grown grasses and legumes are April 1 to June 1 and August 15 to September 15. However, on sands under center pivots with ground cover in place, planting can be done anytime from March 1 to September 15 with selected species. Late summer seeding is *safer* than spring seeding.

Either remove the previous crop as hay, pre-irrigate, and drill seed *directly* into stubble or pasture to remove excess vegetation, spray with herbicide, irrigate and drill in new seeding. Following winter wheat, remove *excess straw*, irrigate, and seed into stubble. Control volunteer grain with selective herbicide if necessary.

On sandy soil, where the previous crop left little residue, a nurse crop should be established prior to seeding alfalfa or pasture. Treat possible trouble spots with well anchored straw or other mulch.

ASPARAGUS seedbeds are prepared by hilling in a cross wind direction in the fall of the year preceding asparagus planting. Drill wheat into the hilled ground. In late February treat the furrows with *herbicide*,

leaving wheat on the hills as a windbreak for each row. Till sprayed furrows to incorporate the dead wheat and plant asparagus. Flail off remaining cover after asparagus ferns are developed.

SUGARBEET planting methods have not been as well developed for easily eroded sandy soils. Sugar beets can be seeded into a *fall seeded cover crop* such as wheat. Till narrow row-width strips of wheat in a cross wind direction before wheat is well tillered. Repeat this tillage before planting sugar beets. Use pre-plant herbicide if necessary. Control between-row cover with chemical or tillage *later* in the season, after the beet plants have attained sufficient height to control wind erosion.

CORN for grain, silage, or sweet corn should be planted with *minimum tillage* in stubble or cover crop. Use selective herbicides for weed and cover crop control. Corn can be seeded into *trashy cloddy surface* and irrigated up. Planting corn in sandy land with little or no residue *is very risky*. Haul in straw before planting if residue cover is light.

FALL SMALL GRAINS should be planted in September, preferably by September 15. After early potatoes, plant sudangrass, grain sorghum, corn or other warm weather crop and plant fall cereal into 6 to 10 inch stubble of short term crop after harvest of hay, silage, or greenchop. Surface protection with straw, manure, or other mulch may be required for successful establishment of winter cereals if seeded after October 1.

GRAPES should be established in the early spring in *winter wheat* established the previous fall. Leave unseeded cross wind oriented rows three feet in width for planting of grapes. Alternatively, drill winter wheat solid and in the spring kill three foot strips with herbicide where the grapes are to be planted.

GRASS SEED crops need fine seedbeds, emerge and grow slowly and are often difficult to establish. Pre-irrigate and work while wet with disk and toothed ring roller to form small clods. Plant when field is moist, but not too wet in cross wind oriented drill rows. Use a chisel point to make clods between rows. Use cereal strips for windbreaks at ten foot intervals and mow or cultivate out when no longer needed.

MELONS require special protection because seedlings are easily destroyed by wind-blown sand. Small grain windbreaks protect plants from sand-blasting, increase soil and plant temperature for rapid growth and shelter bees during pollination. Seed solid stands of small grain in the fall. *In late winter* develop seedbed strips in a cross wind row orientation by killing the small grain with herbicide, till and roll to firm. Plant melons when soil temperature is favorable. Before vines reach them, undercut the cereal strips and leave as a surface residue.

PEPPERMINT OR SPEARMINT roots should be planted into a firm wet-disked and rolled seedbed which contains crop residue material. If crop residue is light broadcast straw or manure and anchor with a straight set disk. Use herbicides to control weeds.

POTATOES should be planted in soils containing abundant residues and clods on or near the surface. Irrigate and till while wet. Plant in cross wind rows perpendicular to prevailing winds. Avoid planting late potatoes in extremely sandy problem areas because frequently a

cover crop cannot be established after digging and before freezing. If this is not avoidable, have available adequate straw, manure or other mulch material for surface protection for open overwintering of the field.

Research is in progress on planting potatoes directly into standing cover crop. This will possibly include two applications of chemicals, strips in the late fall or early winter, and a second application in late winter or early spring.

Special Use Areas

Every effort must be made to prevent the exposure of bare loose soil surfaces to winds. This is as true outside of farmed fields as inside. Wind erosion control measures appropriate for non-farmed areas include surface covers (live vegetation, dead vegetation, and other), windbreaks (planted or erected), and soil surface stabilization. In each instance, the following factors must be considered when planning and developing wind erosion control for special land use area:

-Blow control planning should be part of the very *first planning* done for a given site.

-*Have water* available to establish vegetative cover or windbreaks.

-Existing *vegetative* cover provides effective wind erosion control in many cases and should not be disturbed during certain seasons unless an alternative is available for immediate use.

-*Timing* of the first disturbance of a covered soil markedly influences the success and cost of alternative covers or controls. Ground-breaking in some months (winter and spring) can be more disastrous and more expensive to control than in other months.

-*Covers and controls* may be temporary, renewable, or permanent. Each type must be considered for every site. Installation of temporary control is an expense which planning can preclude in many cases.

-When the area under consideration bears traffic (especially vehicular), suitable cover is limited to *non-vegetative material* such as rock, gravel, or paving. For non-traffic or light traffic areas, soil stabilizers such as oils, resins, ligno-sulfonates, water glasses, hygroscopics, or polyelectrolytes must be considered temporary and subject to periodic renewal. The frequency of renewal will depend on the material, weather, rates, and the frequency and nature of the traffic.

-Water alone does *not* provide suitable wind erosion control except while being applied. Then special handling with closely spaced solid set system is necessary.

-If soil sterilants are used, the treated area should be covered immediately with plastic, gravel, barkdust, or other heavy mulch.

For each of the kinds of land use in special areas certain specific recommendations are indicated as follows:

FENCE ROWS: Avoid disturbing the natural vegetation unless extensive earth moving is indicated. If leveling is needed, complete in late summer or early fall. Mulch the surface with straw or other hauled in cover and seed to frost tolerant crop in August or September. Establish windbreak plantings of trees, shrubs, or hedges as quickly as possible.

Contact the local Extension Service or Soil Conservation Service office for suggestions on species, planting dates, spacings, and care. Use suitable chemicals rather than tillage for weed control.

DRIVEWAYS: Provide permanent stabilization of lanes with gravel, rock and oil, or temporary (repeated) stabilization by following manufacturer's recommendations with stabilizing chemicals. Stabilize sides and mid strip with turf grasses. Establish plantings of windbreak shrubs or trees along both sides as season permits. Provide *permanent irrigation system*.

FARMSTEADS: Install irrigation system and establish landscape plantings prior to building construction to the extent possible. Plant into natural vegetation unless extensive leveling is indicated. In this case, provide emergency treatment such as disked in straw and seeding of cover crop until permanent lawns, shrub and tree plantings can be established. Protect temporarily uncovered ground with cross wind snow-fences at a spacing of not more than 10 times the height until cover is established. Other windscreens can be substituted for snow fences providing their barrier density is at least 40%. Sometimes, rows of straw bales (2 high) are helpful. Later these can be scattered and disked in to make a seedbed.

IDLE LAND: Leave natural vegetation undisturbed. Reinforce cover on weak spots with straw mulch, straw bales, or stabilizing agent. Plant permanent windbreaks. Irrigate and fertilize windbreaks. Spacing should not exceed 8 to 10 times the height. Plant for full protection within 2 years with the view of thinning later if desired.

IMPLEMENT AND EQUIPMENT STORAGE: Have irrigation available. Establish windbreaks at 60-foot spacing. Stabilize permanent roadways with rock or asphalt. Leave natural vegetation intact as far as possible. Establish and maintain grass cover in very low traffic intensity areas.

FEEDLOTS AND CORRALS: Establish and maintain windbreaks, i.e., plantings of trees, shrubs, and hedges. Run sprinkler lines along fences for settling dust. Construct fences of planks to act as windbreaks.

FEED STORAGE AREAS, PIT SILOS, ETC.: Establish and maintain windbreak plantings of trees, shrubs, and cover crops. Landscape and sod banks, borders, edges. Cover unvegetated exposed areas with plastic film or rock. Treat roadways, driveways, etc., with surfacing or chemical stabilization.

FIELD ACCESS ROADS: Orient cross wind as much as possible and fit with permanent irrigation line. Irrigate very frequently. Minimize width. Treat heavily and as needed with gravel, barkdust, or road oil.

TURN AREAS: Minimize size. Mulch with disked in straw, manure, bark-dust, etc. and remain in irrigated area.

GRAVEL PITS AND EXCAVATIONS: Orient with long axis North to South. Make relatively narrow and long if possible. Stabilize nearby surfaces with chemical and windscreens. When finished with any given area, shape banks to stabilize slope and seed to native grasses and shrubs through straw mulch. Treat access roads with stabilizers. Cover bare and disturbed areas with straw, temporary windbreaks, rocks or chemical stabilizers depending on relative permanence required and plant permanent windbreaks.

BUILDING CONSTRUCTION SITES: Same as Farmsteads (above) and additionally, provide soil stabilizing treatment for driveways and roadways.

ROAD AND HIGHWAY CONSTRUCTION: Erect windscreens (snow fence or other) across any active dune crossing right-of-way or approaching right-of-way. Stabilize with transplants of dryland vegetation and irrigate until established. Cover cuts, berms and roadbed with rock, asphalt, or concrete within one day of completion. Orient borrow pits as narrow cross wind strips, that is, make length in the cross wind direction.

INDUSTRIAL AND COMMERCIAL SITES: Expose minimum area. Use temporary (snow fence or other) windbreaks across site at windward edge and repeat at 50 foot spacings wherever practicable. Establish and surface permanent driveways as soon as possible. Chemically stabilize non-trafficed temporarily exposed areas. Complete landscaping with lawns, trees, and shrubs using bark dust or straw mulch during establishment of plantings. Use sod instead of seed for starting lawns.

Emergency Measures

For severe wind erosion needing immediate temporary treatment until more permanent arrangements can be made, consider the following:

STRAW, manure, corn cobs, waste sludges, coarse barkdust or other similar materials can stop blowouts only if applied at heavy rates and anchored. Straw should be used at a minimum rate of 3 tons per acre and disked in cross wind with a straight set disk to leave the straw partially buried and protruding several inches from the surface. Corn cobs or manure should be used at rates of at least 5 tons per acre. Rows of unbroken straw bales at right angles to the wind can be used for emergency treatment of blowouts. The rows of bales should be no more than 15 feet apart in the direction of the wind. It is important to start the rows well upwind of the head of the blowout.

ROUGH TILLAGE is one of the most common emergency procedures to stop blowing soil. It requires a chiseling operation which brings damp clods to the surface. This works well for medium or heavier textured soil, but as the sand content increases, clod formation and persistence decreases such that this practice may even be detrimental if residue is buried in the process of emergency tillage.

SPRINKLING WITH WATER will reduce the blowing of soil particles. Sprinkling is only an emergency spot-type procedure since most sprinkler systems do not have enough capacity to keep the surface of an entire field wet.

SOIL STABILIZERS can be used to stabilize a loose surface soil. These are chemical sprays which cement particles together. Several products have been evaluated. See the Extension Service or Soil Conservation Service for further information.

Appendix A

ECONOMIC CONSIDERATIONS

It is safe to say that all segments of the rural society in Eastern Oregon realize the hazards, aggravations, and economic losses that accompany serious blowing of soils. Agriculturally oriented people usually know of the steps and practices that are necessary to control wind erosion.

The central consideration regarding the economics of wind erosion control is to balance the control costs and returns with the present and future needs for the soil resource. The soil resource must be conserved to contribute to both present and future income. The problem is to determine the amount of control to be exercised, recognizing the costs and benefits involved. While the costs are immediately incurred, the benefits may not be immediately realized.

Erosion control practices typically increase the costs of crop production.

-The establishment of a cover crop on a newly developed soil costs $50 to $75 per acre. It may also mean that a crop cannot be grown for harvest during the first year.

-Mulching with straw or other material may cost $40 to $60 per acre for materials and spreading.

-A windbreak of pine trees could cost from $4 to $10 per acre, but would have limited effect in the early years. In addition to this investment, there is partial loss of productive land.

Debt service and interest alone may cost up to $120 per acre during the first year of operation. When taxes, system depreciation, and other fixed capital costs are added, a return in excess of $150 per acre is needed to recover development costs. To meet these obligations, the farmer must often grow a cash crop the first year without the benefit of a cover crop or other conservation measures. Increased loan amounts or delayed principal payments might allow the farmer to establish some control practices during the first year.

Most long term development loans include funds for irrigation pumps, mainline, distribution equipment, and installation. Some provide an amount for land leveling, but none have included any funds for wind erosion control. *However,* short term lenders providing annual production money *are beginning* to recognize the immediate benefits of wind erosion control and may include an amount for this purpose in their loan commitments.

In many cases, the developer or landlord is not the same individual as the farmer. A leasee may be here today and gone tomorrow, and may feel he has no stake in future productivity. Until both developers and landlords insist that their tenants husband the soil, there will be management problems.

The short term benefits of practices to control wind erosion are usually difficult to measure. However:

-There is the cost saving of not having to replant a blown-out crop.

-Saving the value of crop production which is lost due to damage inflicted by wind and blowing soil.

-The decrease in windborne loss of chemicals and nutrients either applied or already available to the crop is a potential benefit.

-Control practices may result in reduced irrigation requirements owing to less evaporation loss.

-Increase in crop yields could also result from the more favorable growing conditions.

While it is impossible to stop wind erosion completely, there is some level of control that is economical from the standpoint of the farmer. It must be remembered that farmers, as other businessmen, will adopt new management practices if they are in their economic interest.[1/] In other words, it should be demonstrated to farmers that wind erosion control is a paying proposition.

It behooves the farmer to use whatever data are available in determining his farming practices. He should provide for an economical level of erosion control, considering not only the present but also the future effects of these practices. If the economical level of conservation from the stand-point of the farmer falls short of what is acceptable to the community, some kind of public assistance may be necessary to prevent pollution and maintain the community's resource base. Public action could include such measures as a change in tax laws, an improvement in credit arrangements, or some type of cost-sharing between farmers and the government.

1/ Erosion may reduce environmental quality to the extent that other segments of society are affected. In that case, laws or regulations may be adopted requiring farmers to control erosion.

Appendix B

LAND AND SOIL

Under consideration in this handbook is an area of approximately 750,000 acres of land in north central Oregon where the average annual precipitation is less than 12 inches. This area is bounded roughly by north latitudes 45°31' and 45°55', and longitudes 119°00 and 120°00 W. The area is confined between the Columbia River on the north, Willow Creek on the West, Willamette baseline on the south and the north-south line through the confluence of the Umatilla County Juniper Canyon with the Columbia on the east.

Geologically this area is a portion of the Umatilla Plains lying on Columbia River basalts and is composed of glacial lake sediments, sand and gravel glacio - alluvial deposits, and loessial silts. Elevations range from 350 feet at high water at the John Day Pool (Umatilla Lake) to a possible maximum economic water lift level at an elevation of 1000 to 1100 feet. This upper limit might be exceeded depending on the possibilities of the use of cooling water from one or more power plants for irrigation.

Topographically, the land area consists of large flats in the north near the river becoming steeper with shorter slopes, and more severely disected by drainage channels further south at higher elevations.

Of the land area in this portion of the Columbia Basin and Columbia Plateau major land resource areas, approximately 450,000 acres is suitable for irrigation. Much of this land was previously considered unsuited for irrigation because the soils were coarse textured or shallow. However, recent developments in irrigation equipment have modified the significance of these parameters. The economies available with continuous move sprinkler systems, where suitable, making small, frequent, relatively uniform applications at high instantaneous rates (too high for all but very sandy soils), on moderately undulating topography suggest a potential for future agricultural development. Approximately 120,000 acres has been brought under irrigation during the 1967-1976 period.

Soil

There is a marked association between the soils of the area and its physiographic features. In considering wind erosion control in the irrigated agriculture of this region, it is sufficient to examine two cases, the coarse sandy soils of the lower Columbia Basin at elevations of 350 to 750 feet, and the silt loam loessial soils of the Columbia Plateau at elevations of 750 to 1100 feet.

The 750 foot elevation contour can serve as a rough dividing line regarding suitability of the center pivot irrigation system. Standard size center pivots are likely to perform satisfactorily on the sandy soils below 750 feet elevation, but are likely to fail on the finer textured soils above 750 feet [1/] causing poor irrigation water distribution,

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1/ See Ore. State Univ. Extension Service Special Report 377, page 53 for application rates, and Ore. State Univ. Expt. Sta. Special Rpt. 324 for intake rates.

poor crops, high runoff and severe water erosion. If the soil is not a sand, infiltration capacity of the soil should be measured and the system selected or designed accordingly.

Columbia Basin: This extends along the Columbia River from the mouth of Juniper Canyon on the east to the confluence of Willow Creek with the Columbia on the West. Most of the land is arid shrub-grassland with a rapidly expanding irrigated agriculture.

Light colored sandy soils overlying gravel outwashes and old lakebed sediments predominate in the area. These wind blown sands and loamy sands are identified on soil maps as Winchester, Quincy, and Koehler soil series.

Native vegetation, consisting primarily of cheatgrass, needlegrass, rabbitbrush and sagebrush though sparse and limited in size due to the low available water storage capacity of these soils, is sufficient to generally stabilize the sands against the prevailing winds. However, naturally occuring blowouts do develop. The soil organic matter content is negligible due to aridity, soil temperatures, and aeration. Susceptibility to wind erosion is extremely high. Annual losses, averaged over large unprotected areas, can be 2 inches or 300 tons per acre per year.

Another important soil is Ephrata sandy loam. This soil is shallower, underlain by hardpan and contains slightly more silt and clay than the Winchester, Quincy, and Koehler. The higher proportion of silt plus clay, promotes some weak cloddiness which reduces the wind erosion hazard. In spite of this difference, Ephrata has extremely high s susceptibility to wind erosion.

The remainder of the soil in the basin is comprised of sandy loams, silts, and silt loams formed on or over old lakebeds. On soil maps these areas are identified as Sagemoor, Sagehill, Taunton, and currently unnamed shallow soils. These soils are slightly less susceptible to wind erosion than those referred to above, but the hazard still is very high. Losses on unprotected areas will average 1½ inches per year.

Loess Mantled Columbia Plateau: Soils of this area, further from the river, and at higher elevations than the Basin, vary greatly in texture, depth to basalt, aspect, ash-content, drainage, hardpans, and contents of stone in the soil mantle. The lighter colored silt loams containing a minimum of stones such as the Ritzville, and Ellisforde series (see the local Soil Conservation Service Office for soil maps) are moderately susceptible to wind erosion. The wind erosion hazard on these soils can become very high because of repeated dry tillage (such as weeding fallow land) pulverizing surface layers. Wet tillage and stubble mulching reduce the wind erosion hazard. The wind erosion hazard of the other plateau soils continues to be pronounced but diminishes as the clay, organic matter, structure, stone, or gravel content increases.

All soils in the area can be wind eroded depending on circumstances. See the local Soil Conservation Service Office about the erodibility of your soil.

Appendix C

CLIMATE AND WEATHER

It is the climate of the area, characterized by high radiation intensities, high maximum temperatures, and prolonged dry spells, along with the sandy rapidly warming rapidly cooling soils which makes this area an attractive resource for development of intensive agriculture. Unfortunately, it is also the climate of the area which makes wind erosion a serious problem. A region north of 45^{o} N latitude with an average growing season of 180 to 205 days above 32^{o} F., sandy soils, and an abundant quantity of good quality irrigation water offers opportunity for pronounced diversification of cropping plans and profitable yields. The latitude is significant because it means long summer days with enhanced opportunity for effective late afternoon and evening photosynthesis. This also, however, means very high evapotranspiration, hence high water requirements of crops.

Aridity: This area is a region of light rainfall (7 to 12 inches per year) with amounts too small for annual dry land farming. The region's climate is characterized by a wet late autumn and winter period. Spring is a drying period followed by a dry summer. The summer may have periods of more than a month with no shower activity (Table C-1).

Table C-1. Mean Monthly and Annual Precipitation, Hermiston, Oregon

Jan	1.20	Jul	0.19
Feb	0.94	Aug	0.13
Mar	0.80	Sep	0.46
Apr	0.61	Oct	0.87
May	0.65	Nov	1.05
Jun	0.76	Dec	1.13
	Total	8.79	

Because this region is clear to only partly cloudy for two thirds of the days in the growing season, air temperatures are high. This and the great movement of air cause a high evaporation rate (Table C-2). Because the area is dry, it is an area where difficulty is experienced in maintaining ground cover. The dryness and some of the soils make it virtually impossible to combat erosion with rough tillage without irrigation.

Table C-2. Average Evaporation Rate from a Class "A" Pan For Nine years at Hermiston, Oregon

Month	Apr	May	Jun	Jul	Aug	Sep	Oct
Evap. Rate	5.08	7.84	9.57	11.79	9.63	6.34	3.35

Wind: The Plateau is one of the windiest areas of the Pacific Northwest. The average wind at Hermiston is about seven miles per hour (mph) and at Shuttler Flats (Gilliam County), a few miles west of the area under consideration, it is about eleven miles per hour. These are high, and mean many prolonged periods with strong winds.

A five-year study showed that at Hermiston the wind was *over 15 mph 30% of the time during March, April, May, and June* (See tables C-3 and C-4). For a mixture of single grained materials (sand particles) under field conditions, smooth and bare, the practical wind speed to initiate movement is about 13 mph at a height of one foot. It can be seen that often the winds are strong enough to cause movement. In contrast, during July, August, September, and October the wind speed at Hermiston was over 15 mph 13% of the time. There is appreciable seasonal variation in winds. This can be important in erosion control for it suggests the possibility of maximizing efforts to concentrate soil uncovering into the quieter parts of the year. Obviously, there are limits on how far one can go, but efforts in this direction could be fruitful.

There is also a daily variation in wind speed. On the average, early morning is appreciable less windy than late afternoon.

Winds are out of the western quarter about 75% of the time in the summer, 60% of the time in the winter. Predictability of wind direction is sufficient to make wind breaks very useful.

Table C-3. Number of occasions when winds at 15 to 19 miles per hour or 20 or greater miles per hour lasting the designated duration occurred at Shutler Flats (Gilliam County, Oregon) for the period 1967, 1968, 1969.

Month and Windspeed Range	Hours of Duration																
	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
May																	
15 to 19 MPH	11	6	4	4	1												
20 or greater	10	9	8	7	7	7	7	5	4	4	4	4	4	2	2	2	2
June																	
15 to 19 MPH	7	3	3	2	2	1											
20 or greater	7	7	6	6	6	6	5	4	4	1	1	1	1	1	1		
July																	
15 to 19 MPH	6	4	2	1													
20 or greater	16	14	11	8	6	6	5	4	3	2	1	1	1	1			
August																	
15 to 19 MPH	15	8	3	2	1	1											
20 or greater	11	11	10	10	8	8	7	7	6	5	3	3	2	2	2	2	2
September																	
15 to 19 MPH	8	5	2	1	1												
20 or greater	11	8	7	6	5	5	4	4	4	1	1						
October																	
15 to 19 MPH	1	1															
20 or greater	4	3	3	3	2	2	1	1	1	1	1						

Farmers with land management experience in the area agree that for successful conservation management one must always be prepared for

winds. Irrigation alone is not enough, but it is important. Soil cover must be provided which has adequate density, durability, and resistance to movement, be it living vegetation, hauled and anchored straw or manure, or the crowns and roots of a previous crop.

Table C-4. Number of occasions when winds at 15 to 19 miles per hour or 20 or greater miles per hour lasting the designated duration occurred at Hermiston (U.S.D.C. Station 2S, Oregon), March through October, 1966-1970 inc.

Month and Windspeed Range	Hours of Duration															
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Mar																
15 to 19 MPH	30	24	11	6	10	4	1	1								
20 or greater	11	4	7	1	3			1	1	1						1
Apr																
15 to 19 MPH	53	29	27	14	9	2	3	1	5							1
20 or greater	20	18	10	7	4	2	1	1	3	2	2	1				
May																
15 to 19 MPH	55	25	11	9	12	9	3	5	1	1						
20 or greater	18	6	5	3	2		1		1	1		1				
Jun																
15 to 19 MPH	53	21	16	11	7	8	1	2		1	1					1
20 or greater	14	5	2													
Jul																
15 to 19 MPH	21	12	8	3	5	3	1		1							
20 or greater	7	5														
Aug																
15 to 19 MPH	21	17	7	5	2	2		1	1			2				
20 or greater	4	5	1	2			1									
Sep																
15 to 19 MPH	30	15	10	2			3	1								
20 or greater	4	5	3	1			1		1							
Oct																
15 to 19 MPH	35	22	13	10	3	1	3	1								
20 or greater	9	7	1	2	2	1	3	1								

Appendix D

Example Soil Conservation Rotations

As pointed out in the general recommendations, long term plans necessarily made at the initiation of development for maximum effectiveness, should include rotation plans. Rotations are necessary to prevent exhaustion or depletion of soil productivity, to diversify the farming operation, to control pests (weeds, insects, diseases, etc), and to assist in effective utilization of byproduct (waste) materials.

For wind erosion control it is desirable to maintain ground cover to the maximum possible extent. This should be kept in mind when cropping patterns and crop rotations are planned. Chart F-1, below, indicates 10 possible rotations extending over a seven year period in which this principle is illustrated. Note that many crops adapted to the area will fit such rotation programs. Furthermore, mixing of various of the 10 alternatives is possible wherever crop break dates correspond. In this fashion, the rotations are flexible and can be adapted to technological developments, personal preferences, or economic considerations.

New rotations can be constructed according to economic and conservation needs by working with the Soil Conservation Service to generate farm conservation plans employing guidelines for wind erosion control on cropland.

Chart D-1. Some Example Rotations for Wind Erosion Control.

Year in the Example Rotation. Note that most start with new land.

Example	1st	2nd	3rd	4th	5th	6th	7th
1	Fall grain first crop new land 9/15-10/15	Grain & stubble cover crop	Early potatoes & cover crop, or double crop corn or sudan grass silage or hay-leave 1.5 T/acre residue for erosion control		Early potatoes & fall grain, or double crop. Then grain in crop stubble	Grain & stubble cover crop	Early potatoes & cover crop or double crop followed by small grain in stubble
2	Fall cover crop on new by 10/15	Early potatoes & cover crop, or double crop. leave 1.5 T/acre residue for erosion control		Early potatoes & fall grain or double crop. then grain	Grain & stubble cover crop	Early potatoes & cover crop or double crop	Early potatoes & cover crop or double crop
3	Straw mulch, early potatoes followed by cover crop	Early potatoes & fall plant grain by 9/15	Grain & stubble cover crop	Late potatoes & mulch trouble spots for winter protection	Early potatoes & fall grain. Plant grain by 9/15	Grain crop & stubble cover crop	Late potatoes & mulch trouble spots for winter protection
4	Straw mulch for potatoes on new land spring & fall mulching	Late potatoes & fall grain. mulch trouble spots	Grain & stubble cover crop	Late potatoes & fall grain. mulch trouble spots	Grain & stubble cover crop	Late potatoes & straw mulch trouble spots	
5	Straw mulch early potatoes & fall grain by 9/15	Grain crop & graze stubble leaving 2 T/acre cover	Dry beans & cover crop (Rototill or disk & roll for spring seedbed	Early potatoes & cover crop or double crop as in example one		Silage corn & stubble 14" tall or interplant grain cover crop	Early potatoes or dry beans & cover crop (Rototill or disk & roll for bean seedbed)
6	Establish fall grain strips 12" wide 12' apart	Watermelons & graze aftermath. leave 1.5 T/acre residue	Potatoes & cover crop or straw mulch cover crop after early potatoes straw mulch after late potatoes		Potatoes & fall grain by 9/15	Grain crop & stubble in strips 12" wide 12' apart	Watermelons & graze aftermath. leave 1.5 T/acre residue
7	New land leave vegetation-12' wide rows-12" wide strips	Watermelons & graze aftermath-leave 1.5 T/acre residue	Field corn & graze stover. Leave 1.5 T/acre for erosion control		Silage corn & no tillage fall grain in 14" stubble	Grain & stubble cover crop	Stubble strips & watermelons
8	Fall plant alfalfa on new land. 9/15 cutoff date	Alfalfa four crop years (or five)				Early potatoes & cover crop or double crop	Early potatoes & alfalfa by 9/15 with spring oat nurse crop
9	Grain crop & establish pasture 10/15 cutoff date or 9/15 if alfalfa in mixture	Continuous long rotations to pasture with one year rotations to fall grain at about six year intervals					
10	Establish long lived crop on protected soils	Continuous long lived crop of asparagus or grapes using conservation cover crops and/or mulches					

A numerical designation of each of 10 examples. They can be mixed if desired.

Appendix E

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