



THE FORAGE AND RANGE RESEARCH LABORATORY

Forage and Range Research Laboratory

CRESTED WHEATGRASS

WHERE DID IT COME FROM?

WHY IS IT HERE?

WHAT DO WE KNOW ABOUT IT!





WHERE DID IT COME FROM?

Professor N.E. Hansen...Special Agent for the Division of Botany USDA...1897-98



“was charged with the mission to secure seeds and plants valuable for a variety of purposes.”

- 706 total collections
- 70 Forages
- 5 collections
 - (4) *A. desertorum*
 - (1) *A. cristatum*

Distributed...Alabama, Indiana, Michigan, Colorado, and Washington



First introduced into the United States in 1898



WHERE DID IT COME FROM?

Westover et al., (1932) reported:

“Small samples of seed (crested wheatgrass) received from Sweden in 1905 and from the Royal Botanical Gardens, Dublin, Ireland, were sown at the Arlington Experiment Farm, Rosslyn, Virginia in 1906, but failed to germinate”.

Second introduction into the United States in 1905



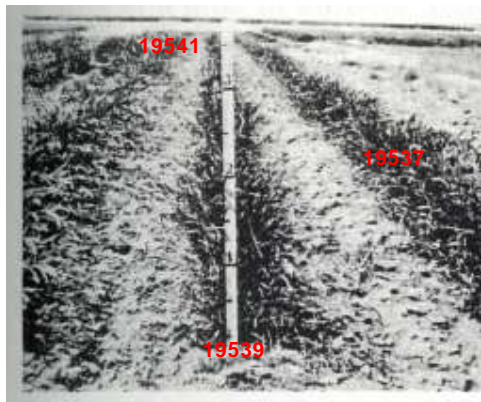
WHERE DID IT COME FROM?

The second introduction of crested wheatgrass by N.E. Hansen came from the same source as the original 1898 collections, and was sent in 1906 through the Moscow Botanical Gardens consisting of:

S.P.I. Nos. 19537 – 19541 *A. desertorum*

S.P.I. No. 19536 *A. cristatum*

4 to 5 lbs of seed were distributed to 15 Experiment Stations from 1907 to 1913



First known picture of CWG grown in North America...Planted 1908...South Dakota



Planting of 19538 at Mandan North Dakota in 1915

Third introduction into the United States in 1905



WHY IS IT HERE?

Changes were taking place that would begin to shape the future of our western rangelands:

- Carey Act of 1894....
- Newlands Act 1902...
- Enlarged Homestead Act 1909...



Large tracks of native grasslands/rangelands were being removed and placed under cultivation for wheat and cereal crops....1905 to 1920

Despite being distributed....crested wheatgrass was still not being used to any great extent as a range species.





EARLY CONCERNS

In addition to increased homesteading in the west, there were other concerns being raised:

- **1898** – H.L. Bentley expressed alarm over range injury resulting from overgrazing in Central Texas.
- **1899** – Jared Smith reported grazing problems in the Southwest.
- **1903** – Public lands commission report that 1400 stockmen in 16 states.....present range conditions.....greater portion of the public grazing land is not supporting the number of stock they formally did.





NEED CREATED?

Over grazing



Homestead Acts



Dust Bowl 1930's

- Homestead acts,
- Overgrazing
- Drought
- Great depression

Brought home to the nation that
renewable natural resources (soil
and water) were not
inexhaustible.....

Drought



We begin to
see the large
scale planting
of crested
wheatgrass



NEED CREATED?

These events (breaking out native grass and rangelands and subsequent events) have been referred to by some as “the greatest ecological disaster in America?”





Crested wheatgrass 'Fairway'

1927 – Distribution of 'Fairway' crested wheatgrass

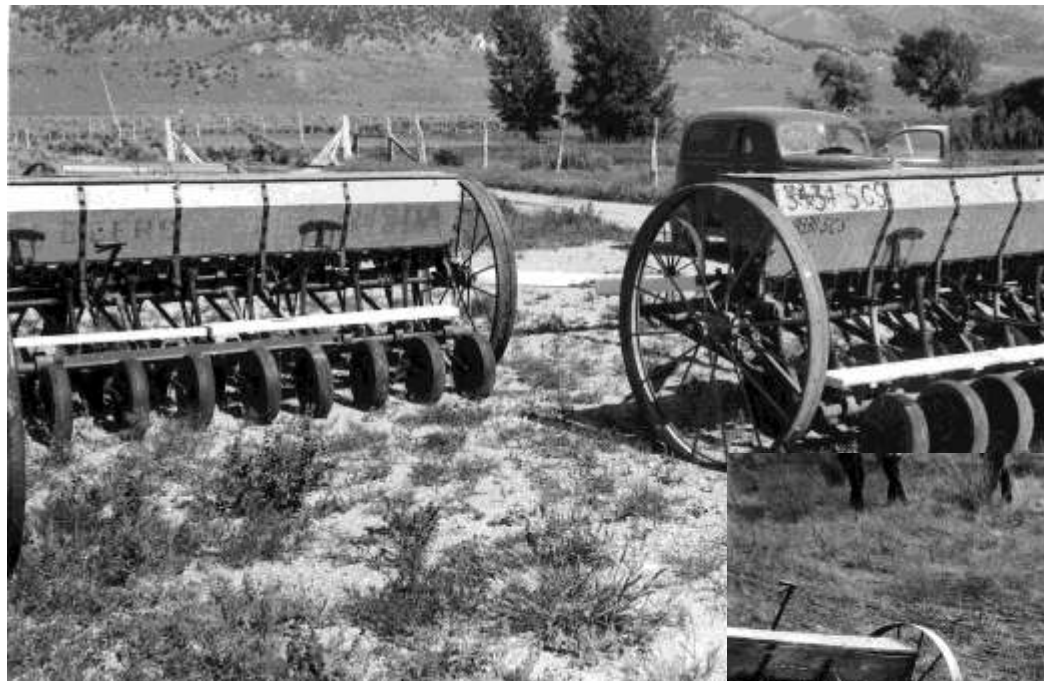
- Not officially released until 1932...Agriculture Canada.
- Selected from the original PI 19536 collections made by N.E. Hansen.
- It is leafier and more procumbent, but less drought tolerant than tetraploid standard types.
- Diploid type ($2n=14$).

Note: Until ~ 1950 crested wheatgrass was considered one species *A. cristatum*....in the 1950's the diploid-type was treated as *A. cristatum* and the tetraploid-type as *A. desertorum*up to 1950 both types were mixed in seed lots.





Crested wheatgrass 'Fairway'



**1930 – 1950 continue
to seed rangeland
seedings of 'Fairway'
crested wheatgrass**

**Still widely used in
rangeland reseeding
programs in Canada**





Crested wheatgrass 1950's

1950's....First efforts made to improve crested wheatgrass in North America

1953.....Release of the cultivar 'Nordan' (*A. desertorum*) crested wheatgrass...USDA-ARS & North Dakota AES

- Originated from PI 469225.....selection made from an old 1937 crested wheatgrass planting in Dickinson North Dakota...probably from a mixed 'Fairway' planting?
- Under went 2-cycles of selection for upright growth habit, larger sized seeds, and good seedling establishment.....
- Nordan continues to be used in many of the rangeland plantings today.

1953....Release of the cultivar 'Summit' (*A. desertorum*) crested wheatgrass....Agriculture Canada....Originated from western Siberia, USSR....Problems with seed processing



Siberian wheatgrass 1950's

First release of Siberian wheatgrass (*A. fragile*)'P-27' by the NRCS & SCS Pullman, WA (1953)

- Originally collected in 1934-35 Kazakhstan Region
.... Westover-Enlow expedition
- Narrow, awnless heads; fine-leafy stems; drought
resistence (remains green); good seedling
establishment; good seed yields; and adapted
to lighter/sandy droughty soils.



Crested wheatgrass – 1960-80's

Research....

- **Taxonomy/Classification**
- **Plant Systematics**
- **Species Relationships**
- **Genetics**



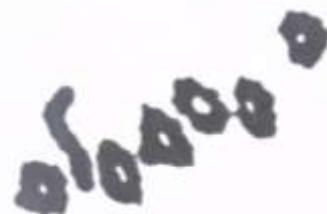
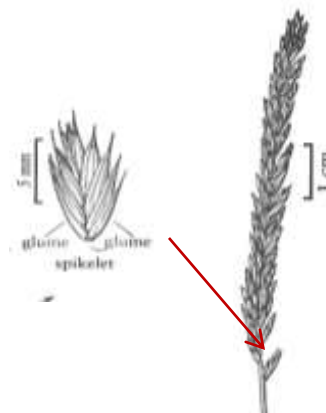
Crested wheatgrass – Research

Taxonomy....

A.S. Hitchcock1935 treatment of *Agropyron* created an extremely large genus comprised of those grass species that had one spikelet per node.

Nevski/Tzvelev....1934/1976 treatment of *Agropyron* is restricted to the crested and Siberian wheatgrasses. ...based on morphology and adaptation.

Dewey/ A. Love....1984/1986 proposed various treatments of *Agropyron* based on genome relationships (i.e., fertility in hybrids, seed set, and chromosome pairing).



In the narrow sense, the genus *Agropyron* is restricted to the crested and Siberian wheatgrass complexes.....all native to Eurasia.



Crested wheatgrass 1960-80's

Species and synonyms	Typical Characteristics
<u>A. cristatum</u> sensu lato (A. <u>pectinatum</u>) (A. <u>pectiniforme</u>) (A. <u>cristatiforme</u>) (A. <u>imbricatum</u>) (A. <u>michnoi</u>)	Spikes broad, pectinate. Spikelets diverging from rachis at angles from 45° to 90°. Glumes not appressed to lemmas, giving the spike a bristly appearance. Lemmas with short, straight awns to 5 mm.
<u>A. desertorum</u>	Spikes subcylindrical, oblong to linear. Spikelets diverging from rachis at angles from 30° to 45°. Glumes appressed to lemmas. Lemmas with short, straight awns to 3 mm.
<u>A. fragile</u> (A. <u>sibiricum</u>) (A. <u>mongolicum</u>)	Spikes linear. Spikelets diverging from rachis at angles <30°. Glumes appressed to lemmas. Lemmas mucronate or awnless.

A. cristatum



A. desertorum



A. fragile



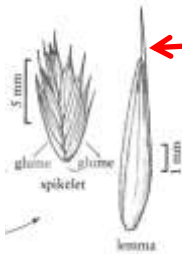


Crested wheatgrass 2000...

Flora North America

A. cristatum (crested wheatgrass)

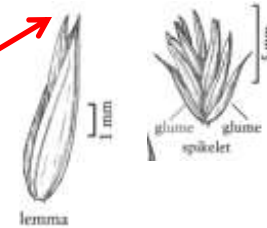
A. desertorum
A. pectinatum



- Lemmas usually awned
- Lemmas usually awnless

A. fragile (Siberian wheatgrass)

A. sibiricum
A. mongolicum



- Spikes narrow to broadly lanceolate, rectangular, or ovate in outline



- Spikes linear to narrowly lanceolate in outline





What Did We Learn 1960-80's

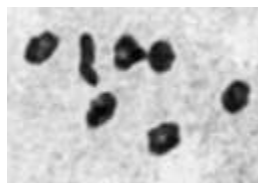
AGROPYRON Gaertner - 1770

Type Species – *Agropyron cristatum* (L.) Gaertn.

Genome – 'P'

Chromosome no. $2n=14$, **28**, and 42 (Autopolyploids)

Fairway-type



Standard-type



Distribution & Characteristics:

- About 10 species, all native to Eurasia. Contains only the crested wheatgrasses....
- Includes *A. cristatum*, *A. desertorum*, and *A. fragile* (= *A. sibiricum*).
- Cross-pollinating

Species and primary source	$2n$	Accessions	No. plants	Number of selfed seed/spike	
				Range	Mean
<i>A. cristatum</i> (U.S.S.R.)	14	5	13	0.0–0.8	0.1
<i>A. cristatum</i> (U.S.S.R.)	28	16	73	0.0–7.2	0.7
<i>A. cristatum</i> (Iran)	42	12	63	0.0–16.0	1.2
<i>A. desertorum</i> (U.S.S.R.)	28	18	65	0.0–30.6	2.4
<i>A. mongolicum</i> Keng (China)	14	6	18	0.0–8.0	1.0
<i>A. fragile</i> (U.S.S.R.)	28	2	7	0.0–17.2	4.0



Origin of tetraploid CWG

Hybridization



A. cristatum (2x)

X



A. mongolicum (2x)



F₁ hybrid

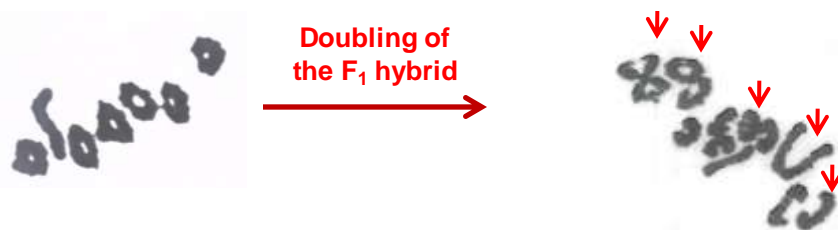




Origin of tetraploid CWG

F1 Hybrid

- Crossing barriers are low (300 seeds/10 spikelets)
- Stainable pollen (2 – 56%)
- OP seed from 14 F₁ hybrids (3 - 2,980 seed plant⁻¹)
- Chromosome pairing complete in 25% of cells



- Hybrids morphologically intermediate... resembling *A. desertorum*



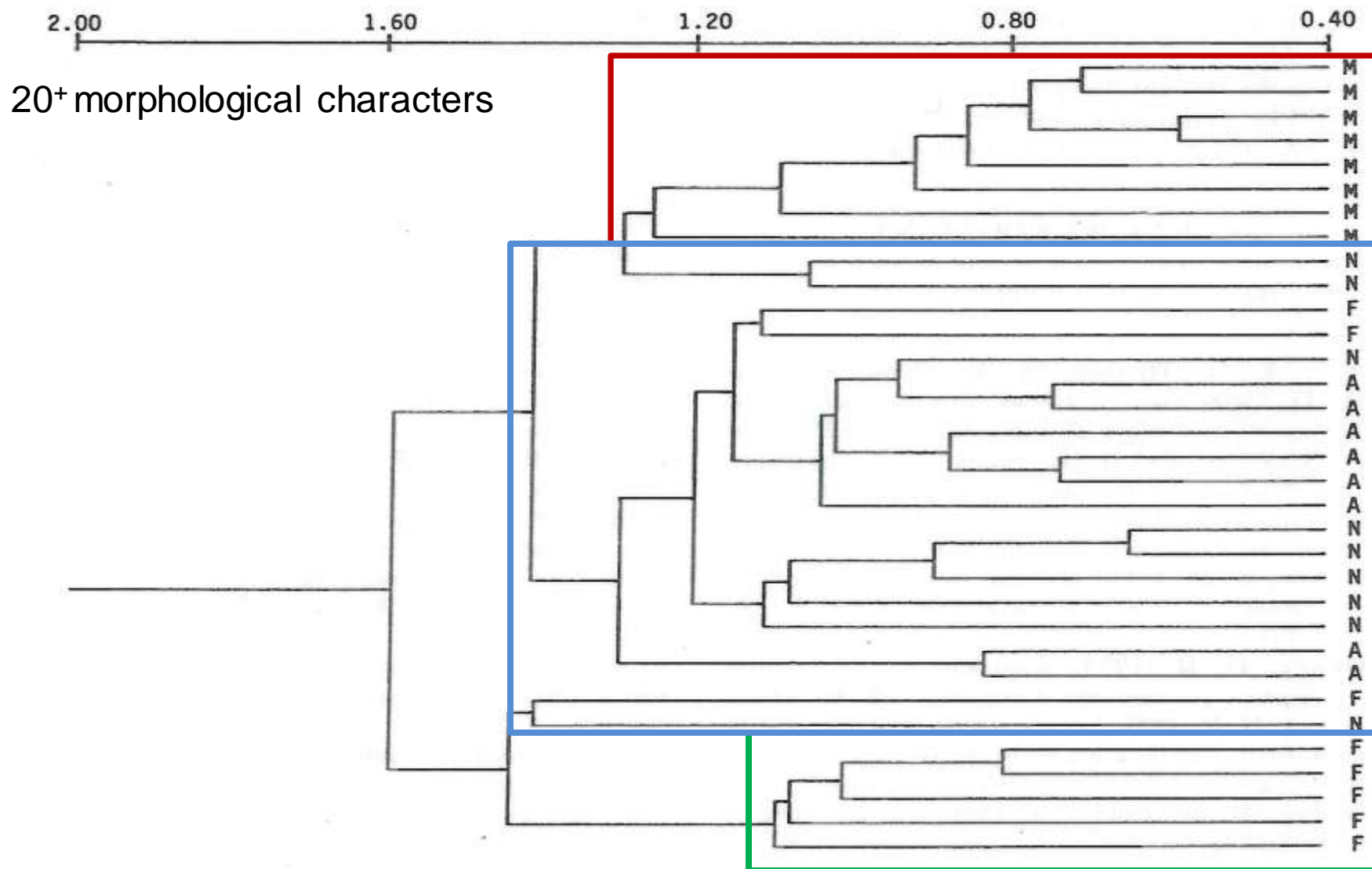
F₁ hybrid



A. desertorum (4x)



Origin of tetraploid CWG





Crested wheatgrass Cultivars 1960-80's

'Parkway' 1969 (*A. cristatum*) Direct selection made from
'Fairway' Agriculture Canada

- 2-cycles of selection
- Improved plant vigor (7-10%) increase in dry matter production
- Increased height
- Increased leafiness



'Ruff' 1974 (*A. cristatum*) Selection from within 7-
seed lots of **'Fairway' USDA-ARS/Nebraska AES**

- 3-cycles of selection
- Drought tolerance
- Recommended rangelands roadsides, parks, playgrounds, and
as a component in conservations plantings.



Environmental Changes 1960-00's ...



Cheatgrass can take over a landscape and result in increased wildfires, loss of soil structure, perennial plant cover etc.

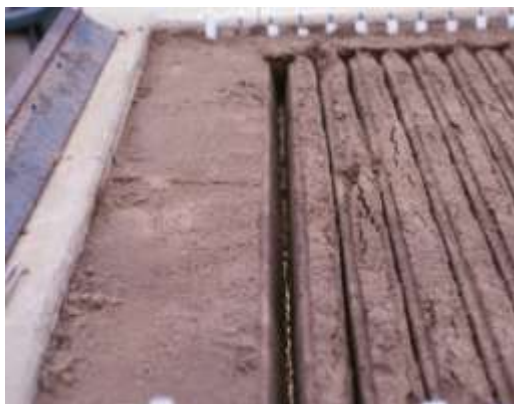




Trait Enhancement 1980 -90's ...

Rapid seedling establishment

selection for individual lines that germinate and emerge from a deep seeding depth (3 inches).



Ability to out-compete weedy species





Crested wheatgrass Cultivars 1980-00's

'Ephraim'.... 1983 (*A. cristatum*-4x) ... Direct selection made from PI 109012 USDA-FS Collected near Ankara, Turkey (Westover 1935)

- No plant selection
- Seed increase and release
- Noted for its Capacity to produce rhizomes, which with adequate water are present by the 2nd or 3rd year.



'RoadCrest'.... 1998 (*A. cristatum*-4x) ... Originated from two collections near Ankara (Ezvet)....USDA-ARS

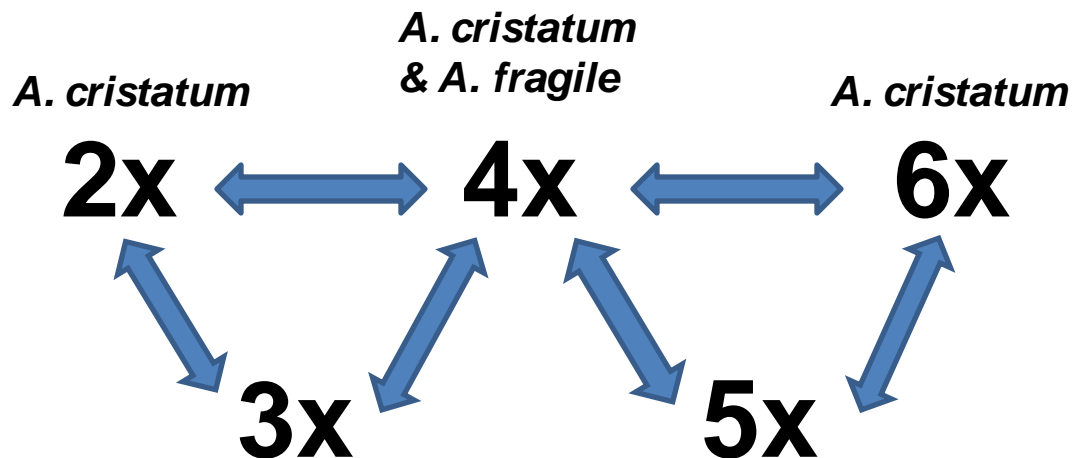




Crested wheatgrass Cultivars 1980-00's

Interploidy- Plant Improvement

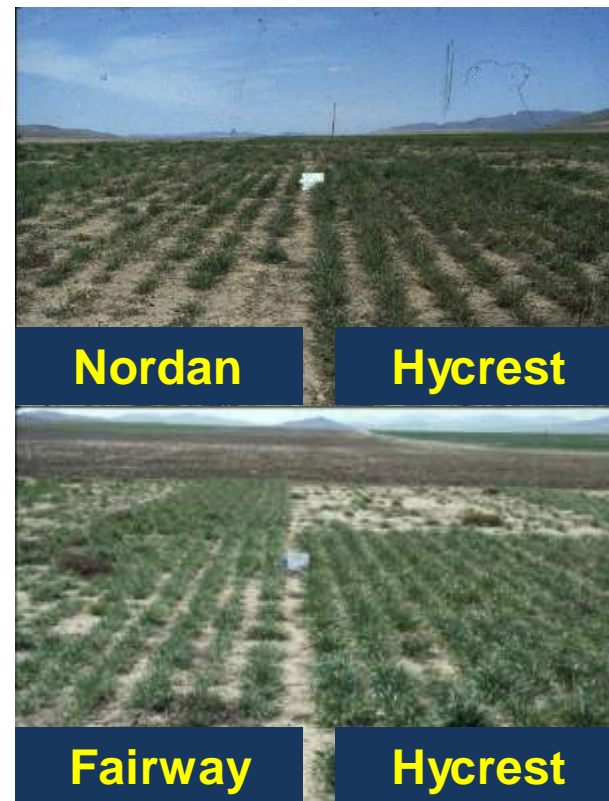
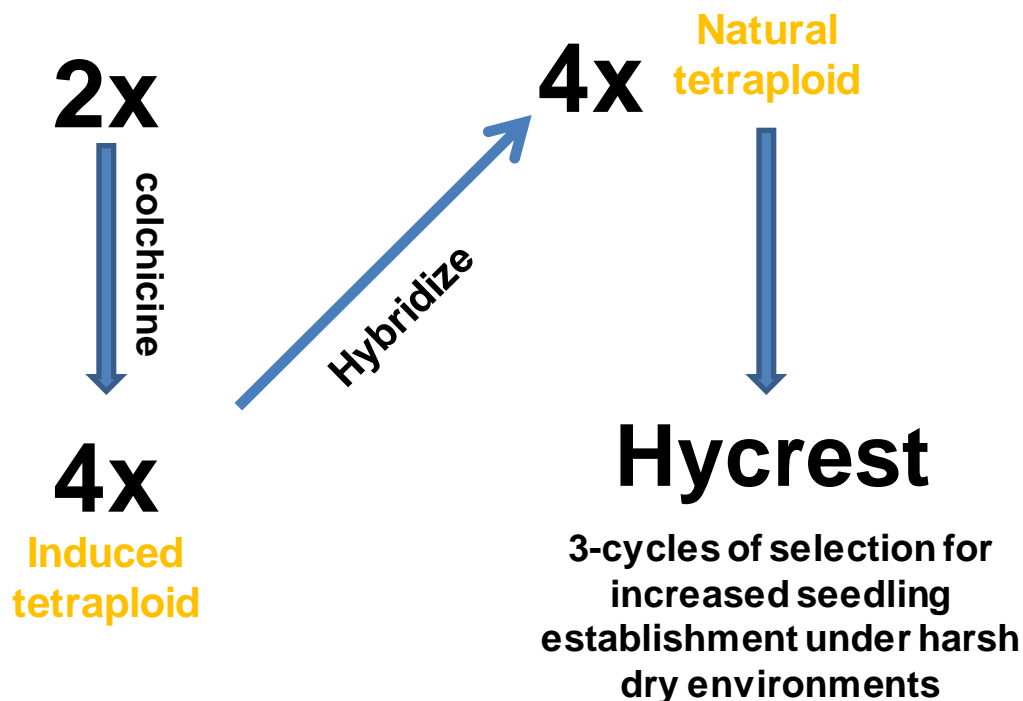
Based on chromosome pairing at the three ploidy levels (2x, 4x, and 6x), and interploidy hybrids, all species in the crested wheatgrass complex was founded on one basic genome and can be treated as a single gene pool.





Crested wheatgrass Cultivars 1980-00's

'Hycrest'.... 1984 (*A. cristatum* x *A. desertorum*-4x hybrid) ...
 USDA-ARS....First interploidy (species) crested wheatgrass cultivar
 released....tends to be larger and more robust than the parental
 species.....increased stand establishment.





Crested wheatgrass Cultivars 1980-00's

'Kirk'.... 1987 (*A. cristatum*-4x) ... Agriculture Canada....1968 introduction from Turku, Finland.... Allowed to outcross with nine local strains and four European introduction

- Two cycles of selection for vigor, fertility, reduced seed shattering awn development.
- 'Kirk' has spike characteristics of *A. cristatum*, its upright growth habit similar to *A. desertorum*.

'Douglas'.... 1994 (*A. cristatum*-6x) ... USDA-ARS....Derived from hybrid between accessions from the former Soviet Union (PI 406442), three from Iran (PI 401076, 401080, and 401085), and one accession from Turkey (PI 406442).

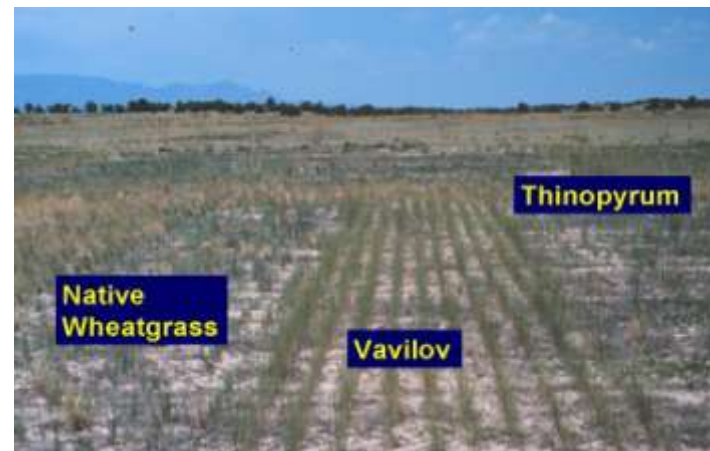
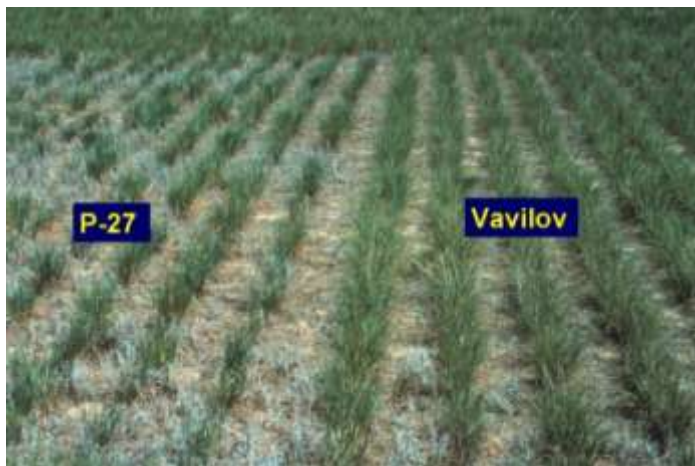




Siberian wheatgrass 1980-00's

'Vavilov' 1994 (*A. fragile-4x*) ... USDA-ARS....Hybrids of parental material originating from U.S.S.R and Turkey

- Three cycles of selection for vigor, seed production, and forage yield
- 'Vavilov' has significantly better seedling establishment than P-27
- Better adapted to sandy dry soils than typical crested wheatgrass

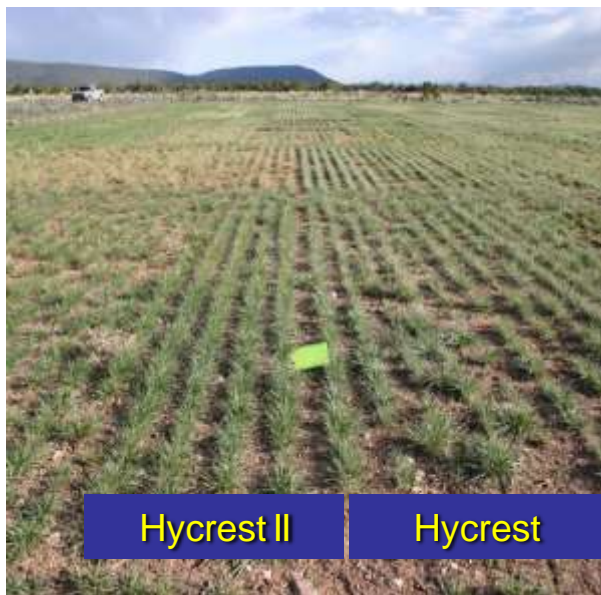




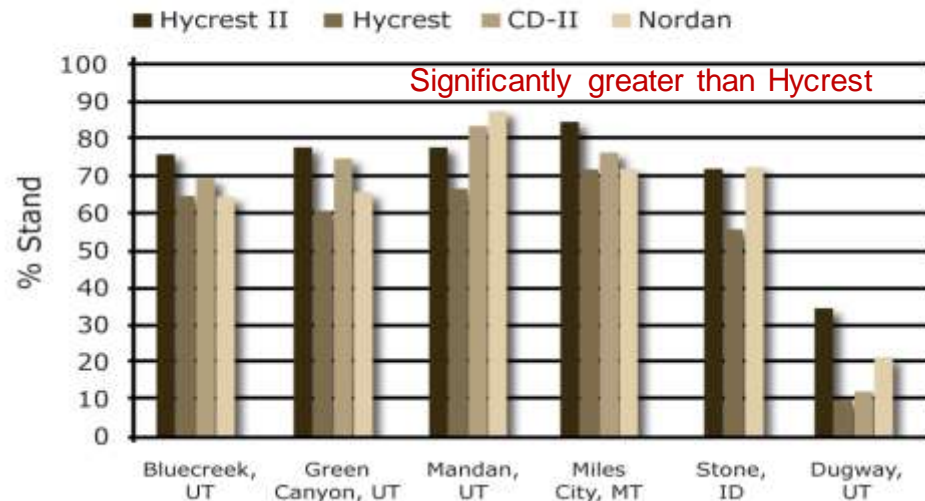
Crested wheatgrass Cultivars 2000-

'Hycrest II' 2008 (*A. cristatum*-4x) ... USDA-ARS....One of the original parents to Hycrest....Increased seedling establishment.

2x $\xrightarrow{\text{colchicine}}$ 4x



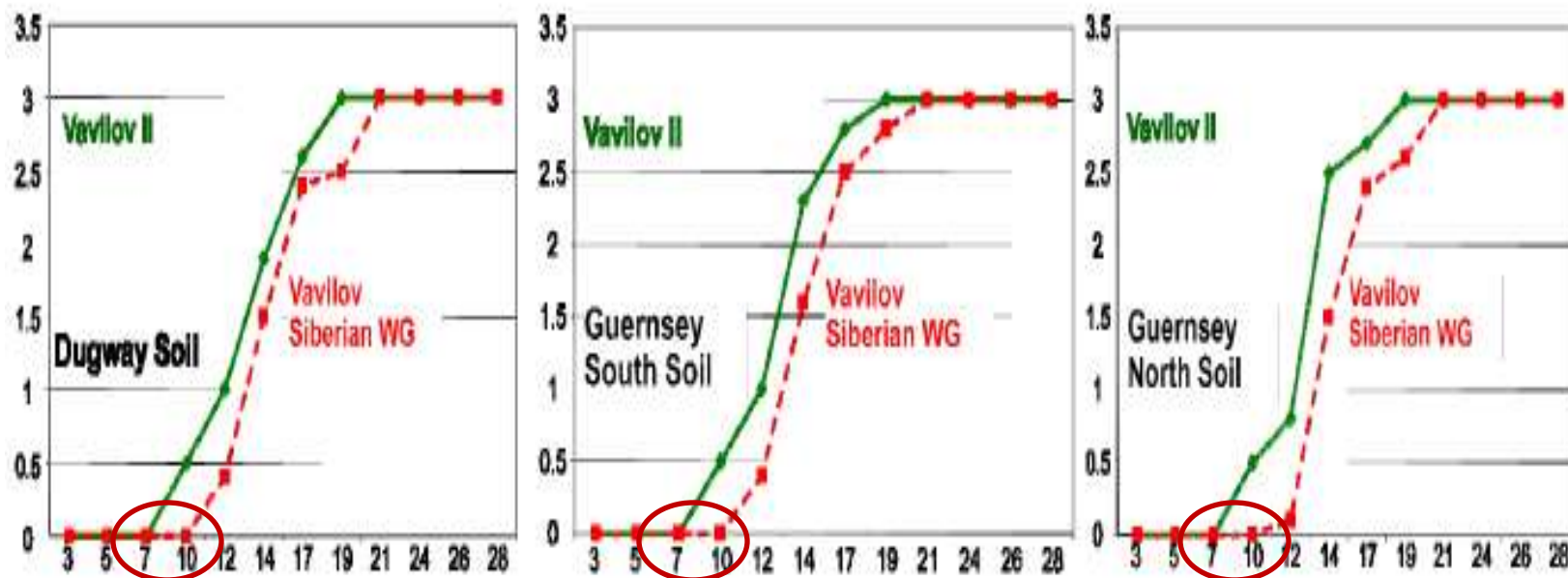
Stand Establishment





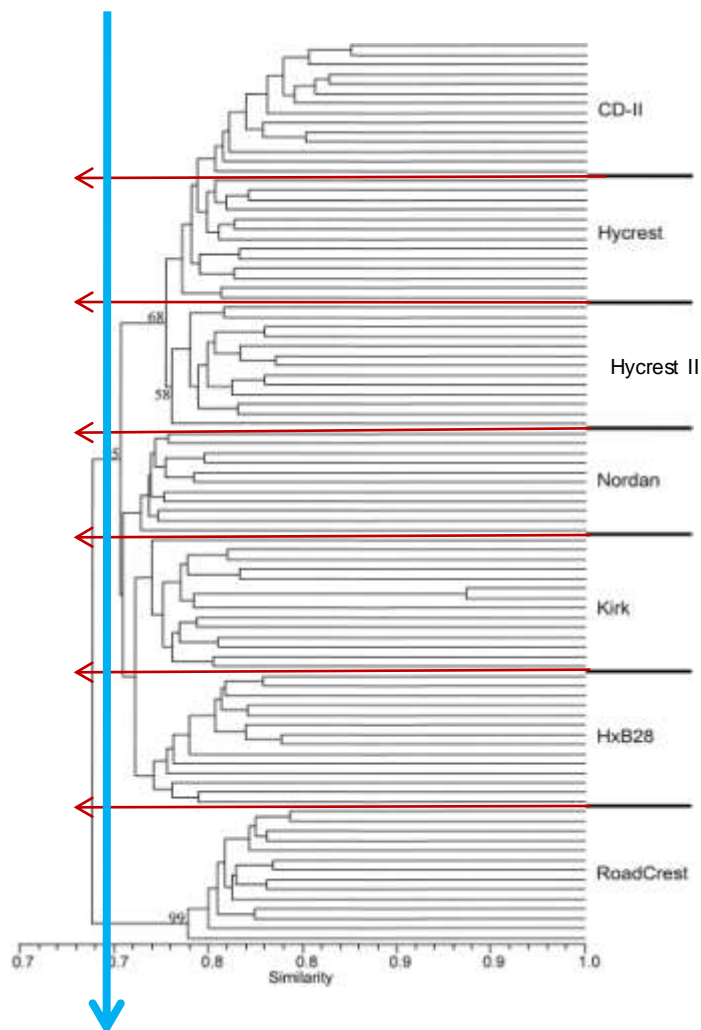
Siberian wheatgrass 2000-

'Vavilov II'.... 2008 (*A. fragile*-4x) ... USDA-ARS....70% derived from the cultivar Vavilov (plants selected under extreme drought) and 30% from collections made in 1988 in Kazakhstan...Increased seedling germination, establishment and persistence over Vavilov.

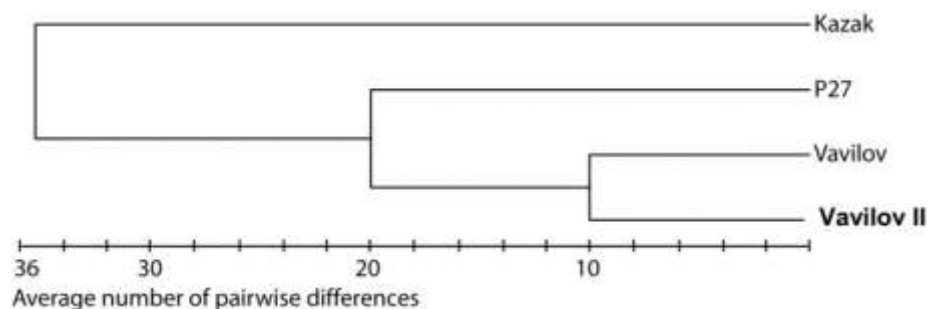




Cultivar Relationships



All crested and Siberian wheatgrass cultivars are closely related genetically, but yet unique





Closing Thoughts CWG



**These events
have been
referred to by
some as “the
greatest
ecological
disaster in
America?”**



**Generations
from
now.....how will
they be
referring to the
affects of
invasive
annuals on our
rangelands?**





Closing Thoughts CWG

Crested Wheatgrass

Villain



Savior



Crested wheatgrass 1960-80's

How do we explain the observed variation?



Variation in spike types of crested wheatgrass (*Agropyron*)



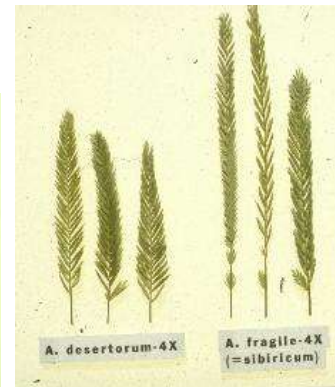
Crested wheatgrass 1960-80's

Hypothesis....Hybridization between closely related diploid taxa followed by chromosome doubling

- Only one type of diploid, broad-spiked *A. cristatum* (Fairway)

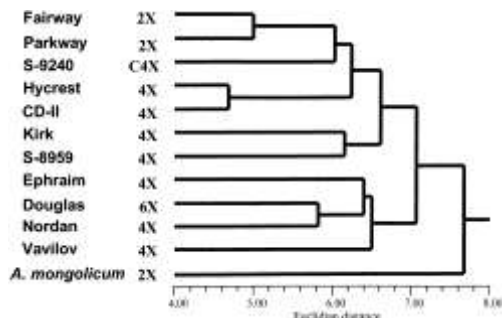


- Many types of tetraploids from broad to narrow-spiked, *A. cristatum*, *A. desertorum*, *A. fragile* etc.



1980

Discovery of a narrow-spiked diploid, *A. mongolicum*, in China





<u>Konstantinov (1923)</u>	<u>Nevski (1934)</u>	<u>Jones (1960)</u>	<u>Tzvelev (1976)</u>	<u>Löve (1983)</u>
<u>A. cristatum</u>	<u>A. cristatum</u>	<u>A. cristatum</u>	<u>A. cristatum</u>	<u>A. cristatum</u>
<u>A. desertorum</u>	<u>A. imbricatum</u>	<u>A. sibiricum</u>	ssp. <u>cristatum</u>	ssp. <u>cristatum</u>
	<u>A. pectiniforme</u>	<u>A. pectiniforme</u>	ssp. <u>pectinatum</u>	ssp. <u>imbricatum</u>
	<u>A. pinifolium</u>		ssp. <u>puberulum</u>	ssp. <u>michnoi</u>
	<u>A. michnoi</u>		ssp. <u>tarbagataicum</u>	ssp. <u>nathaliae</u>
	<u>A. ponticum</u>		ssp. <u>kazachstanicum</u>	ssp. <u>puberulum</u>
	<u>A. badamense</u>		ssp. <u>baicalense</u>	ssp. <u>ponticum</u>
	<u>A. desertorum</u>		ssp. <u>sabulosum</u>	ssp. <u>tarbagataicum</u>
	<u>A. sibiricum</u>		ssp. <u>ponticum</u>	ssp. <u>kazachstanicum</u>
	<u>A. fragile</u>		ssp. <u>sclerophyllum</u>	ssp. <u>sclerophyllum</u>
	<u>A. cimmericum</u>		<u>A. michnoi</u>	ssp. <u>stepposum</u>
	<u>A. tanaiticum</u>		ssp. <u>michnoi</u>	ssp. <u>birjutczenae</u>
	<u>A. dasyanthum</u>		ssp. <u>nathaliae</u>	ssp. <u>bulbosum</u>
			<u>A. badamense</u>	ssp. <u>eriksonii</u>
			<u>A. desertorum</u>	ssp. <u>badamense</u>
			<u>A. fragile</u>	ssp. <u>desertorum</u>
			<u>A. cimmericum</u>	ssp. <u>sibiricum</u>
			<u>A. tanaiticum</u>	ssp. <u>fragile</u>
			<u>A. dasyanthum</u>	ssp. <u>mongolicum</u>
			<u>A. pumilum</u>	ssp. <u>pumilum</u>
			<u>A. krylovianum</u>	ssp. <u>pachyrrhizum</u>
				ssp. <u>dasyanthum</u>
				<u>A. pectiniforme</u>
				ssp. <u>pectiniforme</u>
				ssp. <u>baicalense</u>
				ssp. <u>brandzae</u>
				ssp. <u>sabulosum</u>
				<u>A. deweyi</u>