Biomass Potential in Arizona

Kennith E. Foster,
R. Leslie Rawles,
and Martin M. Karpiscak
Office of Arid Lands Studies,
University of Arizona

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Introduction

Arizona's climate and arable lands support a highly productive agricultural community. In 1970, crop and livestock marketings produced a combined gross income of more than $642 million. By 1978, the annual cash receipts for agricultural products and livestock had risen to $1.5 billion (Arizona Crop and Livestock Reporting Service, 1979).

More than three million hectares (ha) in Arizona are suitable for crop production, but only slightly more than 0.5 million ha are farmed each year. Agricultural production acreage in Arizona since the late 1940s is shown in Figure 1. The primary reason that vast areas of arable land are not irrigated or developed for irrigation is the absence of a dependable and inexpensive water supply.

The future of Arizona agriculture may be influenced significantly by state and federal government programs to develop new water supplies or to control use of existing supplies. Agriculture depletes 90 percent of all groundwater pumped in Arizona. However, limits on future agricultural production could stem from deliberate societal actions to control the amount of water used for irrigation. The projected decline in agricultural acreage through 2020 (Figure 1) assumes that irrigation agriculture in Arizona will be limited to pumping dependable groundwater supplies (Arizona Water Commission, 1977). It is assumed in the projection that efforts will be made to reduce irrigation agriculture to create a balance of supply and use by the year 2000, rather than waiting until use is limited because the cost of pumping becomes excessive.

An Alternative Arid Lands Biomass Production Plan

One alternative for Arizona's agricultural economy is to cultivate low water use crops that grow naturally in arid and semiarid climates. Common Russian Thistle *(Salsola kali* L.*)*, or Tumbleweed, has a high water use efficiency as shown in Table 1.

Russian Thistle was first introduced into the United States by accident in 1873. It was mixed in Eurasian Flax seed and quickly spread over the western United States. The plant has proven to be highly viable and has become a pest in many areas of the country.

Tumbleweed owes its viability to an ability to germinate quickly on minimally disturbed soils, to a high water use efficiency, and to the fact that it is relatively free of diseases and parasites. Figure 2 shows a plant that measured 175 centimeters (cm) in

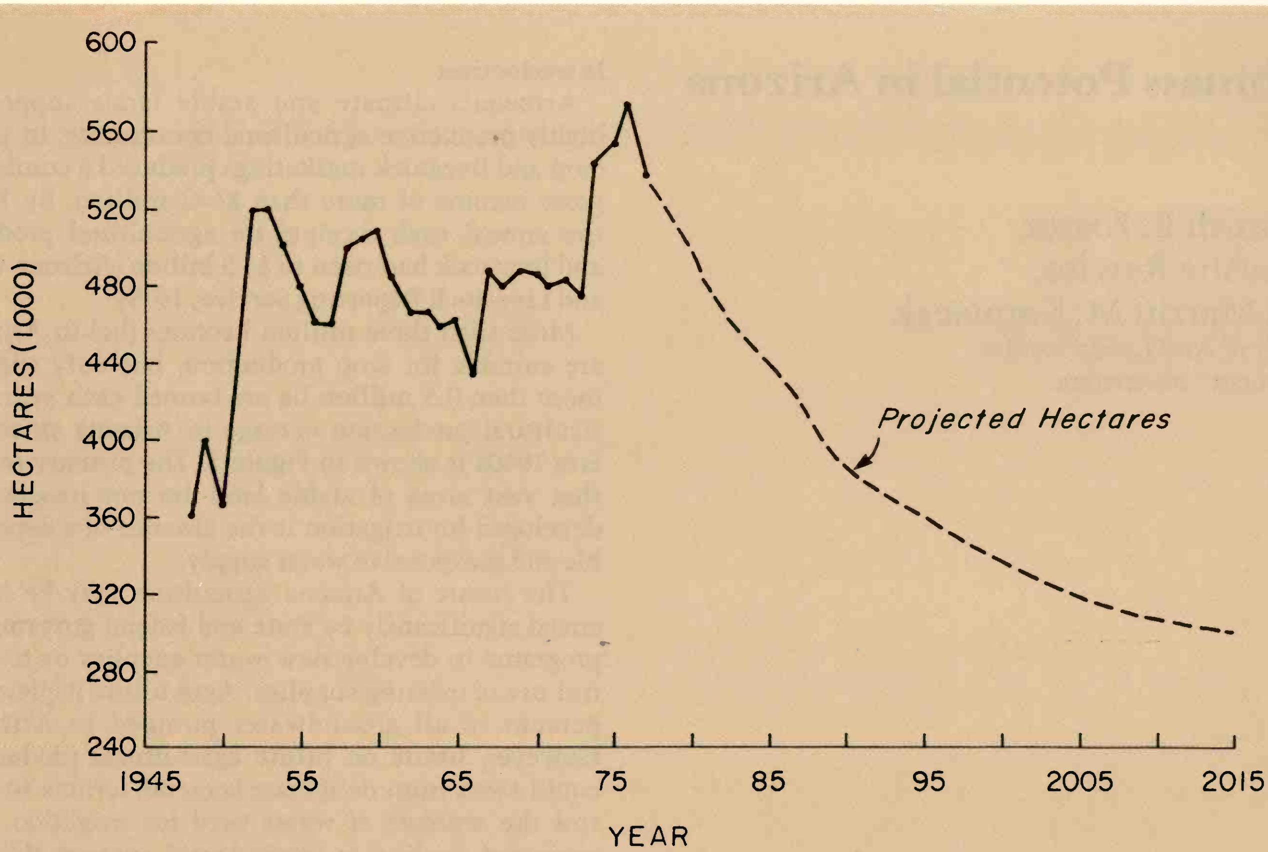

Figure 1. *Chart showing anticipated decrease in croplands producing harvests in Arizona as water available for irrigation decreases, based on data from the Arizona Water Commission, 1977. Also shown are actual numbers of hectares harvested through 1978, from data of the Arizona Crop and Livestock Reporting Service. If crops can be found which use less water, the decrease may be ameliorated.*

height, 213 cm in diameter, and had a dry weight of 9.7 kilograms (kg).

Field surveys of wild Russian Thistle by Meinel et al (1979) indicate that Russian Thistle productivity ranges from 9,000 to 25,000 kg per hectare (kg/ha). Yields obtained from two annual cuttings in New Mexico by Hageman and Fowler (1977) under fertilized and irrigated conditions averaged more than 10,000 kg/ha. Hageman and Fowler reported that optimal yields were generated when 350 millimeters (mm) of combined rainfall and irrigation water were applied. Harvest of 6.4 ha of natural stands in Avra Valley and near Casa Grande, Arizona, yielded 3,100 kg/ha and 1,700 kg/ha respectively. This was a single cutting grown under about 175 to 200 mm of annual rainfall. Figure 3 shows Russian Thistle being cut for harvest in Avra Valley.

Samples of natural stand Russian Thistle were gathered and dried for energy content measurement (Meinel et al, 1979). The energy or heat content was measured in a bomb calorimeter. Values ranged from 15.1×10^6 joule per kilogram (J/kg) to 15.9×10^6 J/kg [*6,500 to 6,800 British Thermal Units per pound (BTU/lb)*]. Field-dried samples processed through a John Deere alfalfa cuber (Figure 4) had an average energy content of 14.7×10^6 J/kg (6,300 BTU/lb). These values fall within the calorific value of lignite, a fuel which varies from 13×10^6 to 18.4×10^6 J/kg (5,580 to 7,920 BTU/lb).

Economic Potential

The estimated cost of producing irrigated and dryland Russian Thistle in the Southwestern United States is reviewed in Table 2. Projected costs for producing 1 ha of Russian Thistle range from \$224.82 dryland to \$708.20 for groundwater irrigated areas. The lowest estimated costs per tonne (t) are in western Arizona using Colorado River water for irrigation and dryland production on the High Plains of Texas. If a cost of \$22.40/t is assumed for processing

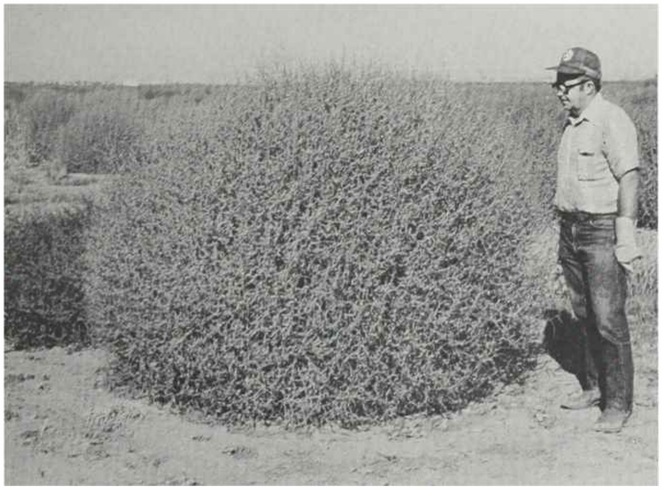

Figure 2. *A large Russian Thistle plant near Casa Grande, Arizona which was found to have a dry weight of 9.7 kg.*

Figure 3. *Russian Thistle being cut and windrowed with a swather.*

Figure 4. *Cubing Russian Thistle with alfalfa harvesting machinery.*

Russian Thistle into logs or pellets, the total cost per 1.06×10^9 J (10^6 BTU) would vary from $4.33 to $6.40. The value of synthetic fireplace logs currently ranges from $14 to $20 per 1.06×10^9 J (10^6 BTU).

Impact of Biomass Development

The possibilities for producing Russian Thistle biomass in Arizona are excellent. Retired agricultural lands may offer the best potential for Russian Thistle production because: 1) there are substantial areas of idle agricultural lands available for economic use; 2) these lands in production would create minimal environmental impacts since established natural desert plant and animal habitats would not be affected; and 3) agriculture could be stimulated in those communities where it has been the prime source of revenue but has been declining due to lack of water.

Nearly 20 percent of all cropland in Arizona is idle. Table 3 shows cropped and fallow acreage in the 14 Arizona counties. In Pinal County alone more than 50,000 ha are idle. Cultivation of Russian Thistle offers a potential economic crop on those areas that are fallow.

The economic impact of Russian Thistle based on the production of a solid fuel consumer product such as an artificial fireplace log, **Tumblelog** (Figure 5), would be substantial. If we assume a yield of only 3,100 kg/ha with a heat content of 14.7×10^6 J/kg

Table 1. Water efficiency values for various plants.

Species	Common name	Efficiency g/kg*
Amaranthus graecizans	(Pigweed)	3.73**
Chaetochloa italica	(Millet)	3.56
Salsola kali	(Russian Thistle, Tumbleweed)	3.54
Amaranthus retroflexus	(Redroot Pigweed)	3.49
Portulaca oleracea	(Purslane)	3.48
Zea mays	(Corn)	2.79
Beta vulgaris	(Sugar Beet)	2.59
Xanthium commune	(Cocklebur)	2.36
Triticum spp.	(Wheat)	2.04
Hordeum spp.	(Barley)	1.93
Avena sativa	(Oats)	1.76
Citrullus vulgaris	(Watermelon)	1.70
Chenopodium album	(Lamb's-quarters)	1.69
Grindelia squarrosa	(Gumweed)	1.68
Gossypium hirsutum	(Cotton)	1.66
Helianthus annuus	(Sunflower)	1.58
Secale cereale	(Rye)	1.52
Polygonum aviculare	(Polygonum)	1.47
Glycine spp.	(Soy Bean)	1.45
Oryza sativa	(Rice)	1.44
Medicago spp.	(Alfalfa)	1.21
Agropyron smithii	(Western Wheatgrass)	0.95

*g/kg = grams dry mass per kilogram of applied water.
**values represent means calculated from data of Briggs and Shantz (1914), Shantz and Piemeisel (1927) and Dillman (1931).

Table 2. Estimated costs to produce one hectare of irrigated and dryland Russian Thistle.*

	Central Arizona (Groundwater)	Western Arizona (Colorado River Water)	Central Arizona, Southern New Mexico and West Texas (Dryland)	High Plains Texas (Dryland)
Variable Costs				
Growing	$258.04	$132.07	$ 56.91	$ 56.91
Harvesting	210.47	210.47	47.87	47.87
Overhead & Management[1]	24.70	24.70	12.35	12.35
Interest on Production Costs[2]	14.80	10.28	3.51	3.51
TOTAL VARIABLE COSTS	$508.01	$377.52	$120.64	$120.64
Fixed Costs				
Machinery[3]	11.04	11.04	10.32	10.32
Water[4]	45.89	—	—	—
Taxes	19.76		19.76	19.76
Rent Value of Land[5]	123.50	123.50	74.10	148.20
TOTAL FIXED COSTS	$200.19	$134.54	$104.18	$178.28
TOTAL PRODUCTION COSTS	$708.20	$512.06	$224.82	$298.92
Yield Per ha (kg)	13,500	13,500	3,400	6,700
Costs Per t	$ 52.46	$ 37.93	$ 66.12	$ 44.61
Costs per 1.06×10^9 J (10^6 BTU)	$ 3.98	$ 2.87	$ 5.05	$ 3.36

*Wright, 1980, Written Communication.
[1]Includes truck, bookkeeping, fencing and tools.
[2]Interest at 12 percent for three months of 1 + 2 + 3.
[3]Includes machinery depreciation for tractor, disk, fertilizer rig and drill.
[4]Takes into account depreciation of pump and well.
[5]Profit assumed to be 6 percent of land value.

*Figure 5. Artificial fireplace logs, **Tumblelogs**, made from Russian Thistle.*

Table 3. Cropland in Arizona counties (1974).*

County	Cropland Hectares	Fallow Hectares	Percent Fallow
Apache	5,220	730	14.0
Cochise	69,200	12,920	18.7
Coconino	3,000	1,170	39.0
Gila	730	360	49.3
Graham	—	—	—
Greenlee	2,510	730	29.1
Maricopa	218,130	29,060	13.3
Mohave	—	—	—
Navajo	—	—	—
Pima	29,950	8,510	28.4
Pinal	158,240	52,650	33.3
Santa Cruz	2,950	1,980	67.1
Yavapai	3,800	1,210	31.8
Yuma	113,720	8,830	7.8
	607,450	118,150	19.5

**From Cropland Atlas of Arizona, 1974.*

(6,300 BTU/lb) and a value of $13.20 retail per 1.06×10^9 J (10^6 BTU) as a fireplace fuel, the total yearly value for Russian Thistle to the economy of Arizona on fallow land would be $68 million.

Fuels derived from biomass such as Russian Thistle may involve considerable amounts of land, but it appears that the great water conservation, energy, economic and environmental gains are greater than the costs. New uses for land not now in production may be developed.

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