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Impacts of Drought on Tribal Economies in Arizona

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Introduction

Drought negatively impacts agricultural productivity, often causing reduced crop yields, damage to pasture/range, and reduced plant growth (Hatfield et al., 2011; Kuwayama et al., 2019). Droughts are particularly concerning for Native American reservations in the arid Southwestern United States, as agricultural production on the reservations provide an important economic base (Deol & Colby, 2018). Close cultural and economic ties to natural resources, geographic remoteness, and economic challenges render Indian reservations very vulnerable to climate change impacts (U.S. Global Change Research Program, 2014). Sustaining agricultural production on tribal lands will become progressively more challenging in the future due to decreased water availability, extended droughts, and changes in precipitation amounts and timing.

The objective of this fact sheet is to illustrate the economic impacts of drought on agriculture and reservation economies in Arizona. Arizona is the fourth driest state in the United States, with average yearly precipitation of 11.24 inches, and 78% of the state experienced abnormally dry conditions over the past 20 years. The results discussed here cover five reservations located in Arizona, including the Hopi Tribe, Navajo Nation, San Carlos Apache Tribe, Tohono O'odham Nation, and White Mountain Apache Tribe. As shown in Table 1, these reservations suffer from poverty and unemployment levels above the United States average and median household income is less than half the United States average. Also, employment in agriculture and related industries is above the United States average on several reservations.

Table 1
Selected Economic Indicators by Reservation (2018)

Geographic Area	Population Below Poverty Level (%)	Employment in Agriculture, Forestry, Fishing/Hunting, and Mining (%)	Unemployment Rate (%)	Median Household Income ($)
Hopi	36.8	0.6	6.4	37,532
Navajo Nation	39.5	3.5	18.1	27,361
San Carlos	47.0	5.4	30.4	31,946
Tohono O'odham	46.3	1.8	28.8	28,750
White Mountain	43.2	2.8	34.4	28,887
United States	11.8	1.8	5.9	64,324

Source. Data from U.S. Census Bureau (2020).

Of all agricultural sales in Arizona, "cattle and calves" represent 17% and "hay/forage" (all irrigated) 10% (USDA NASS, 2019a). Of all cattle inventory and harvested hay/forage acres in Arizona, more than half are produced in reservation counties (66% for cattle, 56% for hay) (USDA NASS, 2020). In addition, available data for the Navajo Nation (Western, Chinle, and Ft. Defiance agencies in Arizona) show that livestock production is very important (roughly 68% of all agricultural sales), and cattle represent roughly 17% of all livestock inventory, following sheep and goats in importance (USDA NASS, 2019b). Table 2 provides 2017 cattle inventory and hay production in acres by reservation.

Table 2

Estimated Cattle Inventory (Head) and Hay Production (Acres) by Reservation

Reservation	Counties (Reservation % Share of County Area)	Cattle Inventory	Hay Production
Hopi	Coconino (5%), Navajo (17%)	7,200	n/a
Navajo Nation	Apache (61%), Coconino (27%), Navajo (40%)	47,100	600
San Carlos	Gila (21%), Graham (37%), Pinal (4%)	18,600	3,600
Tohono O'odham	Maricopa (2%), Pima (42%), Pinal (8%)	33,800	8,100
White Mountain	Apache (7%), Gila (17%), Navajo (10%)	7,300	70

Note. Values calculated using cattle inventory and hay production data by county, reservation share (USDA NASS, 2020).

Calculating Economic Impacts

We used cattle inventory (head) and hay yield (tons/acre) data from the United States Department of Agriculture (USDA) National Agricultural Statistical Service (NASS). Precise cattle inventory and hay production data is not available for each reservation, so values were estimated using available county-level data, reservation share only. Data spanned from 1981 to 2016.

To measure drought, we used the Palmer Drought Severity Index (PDSI) data from the Center for Disease Control and Prevention (CDC), provided by the Cooperative Institute for Climate and Satellites – North Carolina (CICS-NC). PDSI values were compiled using temperature and precipitation data. PDSI can range from -10 to 10, but typically -4 to 4, where 0 represents normal conditions and negative/positive values represent drier/wetter conditions.

First, we applied panel data analysis to examine how drought impacts cattle inventory and hay yields. We then used the regression estimates to calculate cattle and hay production losses under defined drought scenarios. Finally, we estimated the dollar value of cattle and hay production losses for each reservation, which represents the direct impacts of drought. These were used to determine total economic impacts (losses) to each reservation. Total economic impacts include (1) direct impacts (e.g., losses in cattle and hay sectors); (2) indirect impacts (e.g., losses in related sectors, which either sell inputs to the cattle and hay sectors, such as feed, seeds, labor, and veterinary services, or purchase output of cattle and hay sectors, such as food processing); and (3) induced impacts (e.g., losses due to reduced household income and spending throughout the economy, as well as reduced tax revenues).

Drought Impacts on Cattle Inventory and Hay Yields

The impacts of PDSI (drought severity), drought duration (years), and wet periods (years) were used to estimate the impacts of drought on cattle inventory and hay yields. Results show that drought affects cattle inventory and hay yields significantly but differently.

First, drought negatively affects cattle inventory and hay yield during the year that conditions become drier. Specifically, a decrease in PDSI by 1 unit (drier conditions) results in a 0.3% decrease in cattle inventory and 0.4% decrease in hay yields in the first year of drought. Drought also has a long-term negative impact on cattle inventory but no long-term impact on hay yields. Specifically, a one-year duration of very dry conditions (that is, PDSI below -1.9) results in a 1.87% decrease in cattle inventory in the following year. Cattle producers are impacted by drought through reduced feed availability and/or higher feed costs, which may motivate them to cull or sell cattle earlier than planned. The reduction of breeding stock affects post-drought cattle inventory (Shrum et al., 2018).

Direct and Total Economic Impacts of Drought on Tribal Communities

Two assumed drought scenarios and their impact on cattle inventory and hay yields in Table 3 were used to estimate the direct and total economic impacts of drought. Direct losses of drought affecting the cattle sector range from $0.348 million for the Hopi Tribe to $2.267 million for Navajo Nation (see Table 4). Total economic impacts due to cattle sector losses range from $0.805 million for White Mountain Apache to $7.408 million for Tohono O'odham Nation, with total economic losses of $16.2 million for all five reservations (only for areas in Arizona).

We calculated the direct and total impacts with the assumption that very dry conditions (PDSI less than -1.9) last for two years, causing a 3.72% decrease in cattle inventory, but the impacts can be scaled up or down. For example, for a one-year drought, the estimated impacts would be half.

The direct losses of drought for the hay sector range from $300 for White Mountain Apache to $89,000 for Tohono O'odham Nation (see Table 5). Total economic impacts due to hay sector direct losses range from $1,000 for White Mountain Apache to $490,000 for Tohono O'odham Nation, with total economic losses of $577,000 for all four reservations (data not available for the Hopi Tribe).

Again, we calculated direct and total impacts with the assumption that PDSI decreases by 2 units, causing an 0.87% decrease of hay yields, but the impacts can be scaled up or down. For example, for PDSI decrease by 1 unit, the estimated impacts would be half.

Table 3

Drought Scenarios and Impacts on Cattle Inventory and Hay Yields

Product	Scenario Description	Total Impact
Cattle	Two-year drought: PDSI decreases below -1.9 and stays the same for two years, then increases back to the pre-drought level.	-3.72%
Hay	PDSI decreases by 2 units.	-0.87%

Table 4

Economic Impacts of Drought for the Cattle Sector (in Million $)

Reservation	Direct Impacts	Indirect Impacts	Induced Impacts	Total Impacts
Hopi	0.348	0.403	0.107	0.859
Navajo Nation[a]	2.267	2.478	0.570	5.316
San Carlos Apache	0.984	0.517	0.313	1.814
Tohono O'odham Nation	1.805	4.208	1.396	7.408
White Mountain Apache	0.352	0.376	0.077	0.805
Total	5.755	7.983	2.464	16.202

Note. [a] The area of the Navajo Nation located in Arizona.

Conclusions

Reductions in cattle and hay production due to drought result in reduced economic activity in related sectors and significant economic losses for tribal economies. Calculated direct and total economic impacts are larger for the cattle sector than for the hay sector since drought affects cattle production in the long term, and cattle production is more prominent on the reservations in Arizona.

Although estimated disruptions in hay production due to drought are smaller, reduced hay/forage availability may have considerable negative consequences for cattle production if it depends heavily on hay for feed as a result of reduced grazing efficiency.

Hence, droughts represent a threat to tribal economies, where agriculture plays an important role. These results highlight the need for education and policy to improve the ability of reservation agricultural operations to prepare for and respond to drought.

Table 5

Economic Impacts of Drought for the Hay Sector (in Million $)

Reservation	Direct Impacts	Indirect Impacts	Induced Impacts	Total Impacts
Hopi	n/a	n/a	n/a	n/a
Navajo Nation[a]	0.003	0.005	0.002	0.009
San Carlos Apache	0.029	0.031	0.016	0.077
Tohono O'odham Apache	0.089	0.292	0.109	0.490
White Mountain Apache	0.000	0.001	0.000	0.001
Total	0.121	0.328	0.127	0.577

Note. [a] The area of the Navajo Nation located in Arizona.

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