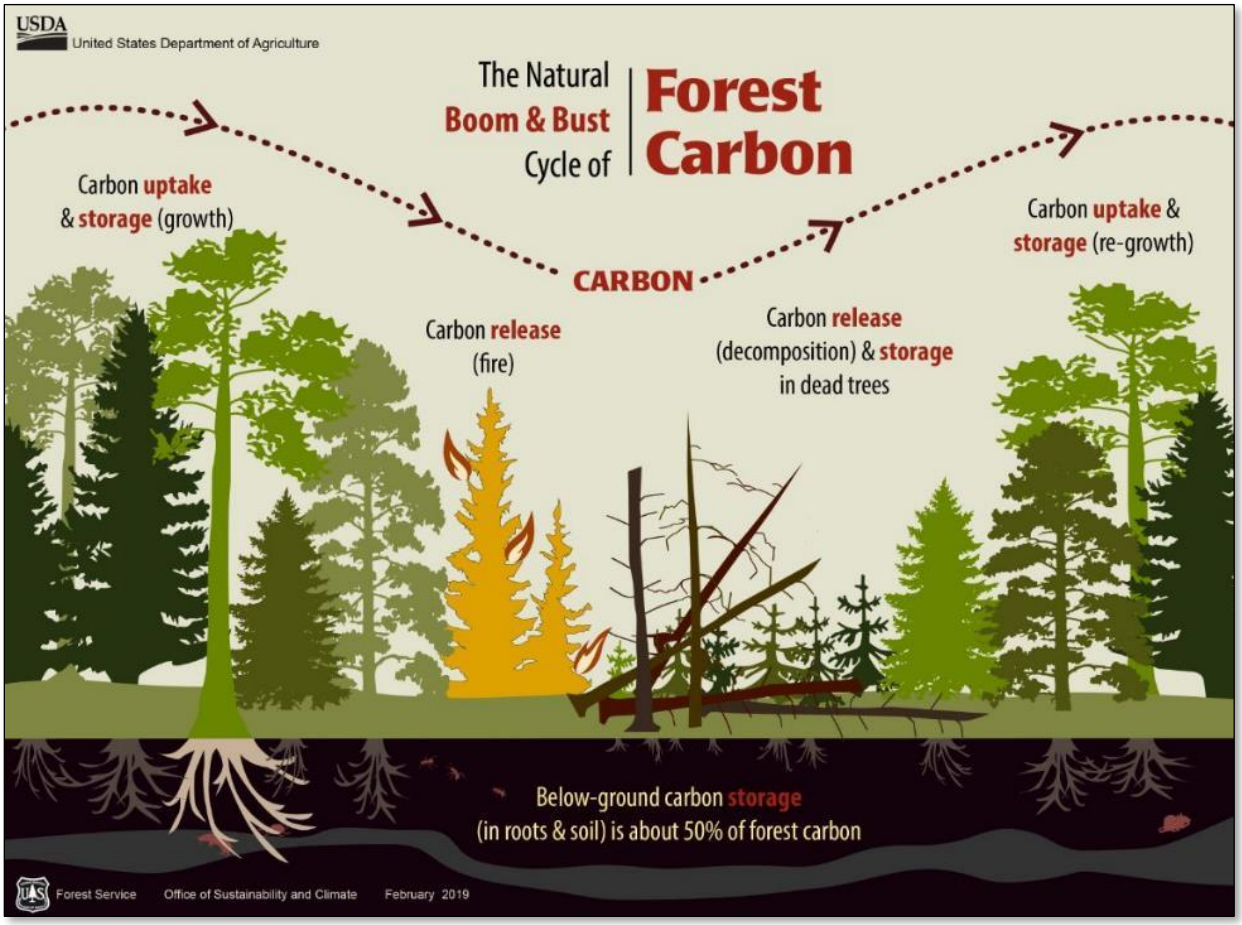
Black Hills National Forest

Draft Forest Assessments:

Carbon



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Chapter 1. Introduction

This assessment describes the amount of carbon stored in the Black Hills National Forest and how natural disturbances and management actions have influenced carbon storage over 30 years. This assessment uses Forest Inventory and Analysis (FIA) data from 1990 and 2020 to capture changes in carbon held in above- and below-ground pools.

The FIA program does not directly measure forest carbon stocks. Instead, the Carbon Calculation Tool (Smith et al. 2007) was utilized to produce estimates of annual carbon stocks and stock change from 1990 to 2020 by summarizing data from two or more FIA survey years. The Carbon Calculation Tool relies on allometric models to convert tree measurements to biomass and carbon.

The estimates that rely on FIA data include uncertainty associated with sampling error (e.g., area estimates are based on a network of plots, not a census), measurement error (e.g., species identification, data entry errors), and model error (e.g., associated with volume, biomass, and carbon equations, interpolation between sampling designs).

In addition, carbon stock estimates contain sampling error associated with the cycle in which inventory plots are measured. FIA plots are resampled about every 10 years in the Western United States, and a full cycle is completed when every plot is measured at least once. However, sampling is designed such that partial inventory cycles provide usable, unbiased samples annually but with higher errors. These baseline estimates may lack some temporal sensitivity because plots are not resampled every year, and recent disturbances may not be incorporated in the estimates if the disturbed plots have not yet been sampled.

Chapter 2. Carbon Dynamics

Significant drivers of carbon dynamics in the Black Hills National Forest are natural disturbances like wildland fire and periodic mountain pine beetle epidemics, and human-induced disturbances associated with removals from commercial timber sale operations. Context for shifts in carbon pools as a function of these three disturbance factors over 25 years is provided in the following three tables. Impacts from several periodic large wildland fires are shown by ranger district in table 1. Mortality from the most recent mountain pine beetle epidemic, which ended in 2016, is shown by ranger district in table 2. Total commercial acreage treated by district is shown in table 3.

Table 1. Wildland fire by ranger district, 1997 to 2021

[Source: Forest large fire history inventory April 2022.]

Ranger District	1997-2001 (acres)	2002-2006 (acres)	2007-2011 (acres)	2012-2016 (acres)	2017-2021 (acres)	Total (acres)
Bearlodge	207	2,263	-	-	-	2,471
Hell Canyon	77,928	12,115	11,198	17,157	332	118,729
Mystic	26,979	10,158	49	481	155	37,821
Northern Hills	-	7,946	205	4,699	-	12,850
Total	105,115	32,482	11,451	11,451	487	171,872

Table 2. Mountain pine beetle mortality by ranger district, 1997 to 2021

[MPB, mountain pine beetle. Source: Forest Health Protection Aerial Detection Surveys 1996 to 2020.]

Ranger District	MPB Affected (acres)	Ponderosa Pine Forest Type (acres)	Ponderosa Pine Forest Area Impacted by MPB Mortality (percent)
Bearlodge	28,167	135,843	21%
Hell Canyon	100,927	367,122	27%
Mystic	131,620	266,384	49%
Northern Hills	151,785	259,731	58%
Total	412,500	1,029,079	40%

Table 3. Total commercial area treated by ranger district, 1997 to 2021

	Bearlodge (acres)	Hell Canyon (acres)	Mystic (acres)	Northern Hills (acres)	Total
Decade 1: 1997-2006	21,741	60,412	65,486	53,745	201,384
Decade 2: 2007-2016	29,758	81,554	53,878	68,664	233,854
Decade 3: 2017 through 2021 only	26,126	28,282	24,030	33,945	112,383
Annual Average: 1997-2021	3,105	6,810	5,736	6,254	21,905

Comparison of carbon stocks in the Black Hills National Forest for 1990 to 2020 reveals that stored carbon decreased from 51.4 million metric tons of carbon in 1990 to 49.4 in 2020, a nearly 4-percent decrease in carbon stocks (table 4). For context, 2 million metric tons of carbon is equivalent to the emissions from approximately 1.6 million passenger vehicles in a year.

Table 4. Forest carbon stock by pool, 1990 to 2020

Carbon Pool	1990 (metric tons)	2020 (metric tons)	Change (metric tons)	Change (percent)
Aboveground Live	16,292,231	12,123,739	-4,168,492	-25.6%
Soil	21,006,753	22,504,083	1,497,330	7.1%
Forest Floor	7,556,683	7,406,087	-150,596	-2.0%
Belowground Live	3,480,497	2,587,656	-892,841	-25.7%
Down Dead	1,314,839	1,339,970	25,131	1.9%
Standing Dead	984,771	2,583,261	1,598,490	162.3
Understory	747,183	851,314	104,131	13.9
Total	51,382,957	49,396,110	-1,986,847	-3.9

The significant influence on carbon pools from wildland fire and mountain pine beetle mortality are shown in table 4, with a 162-percent increase in standing dead biomass. Timber harvesting in the Black Hills National Forest was the primary disturbance influencing carbon stocks from 1990 to 2020, contributing to the more than 25-percent decrease in the above-ground live carbon pool. Timber harvest transfers carbon out of the forest, but most is not lost or emitted directly to the atmosphere. Rather, it may be stored in wood products for a variable duration depending on the product. There is a corresponding decrease in the below-ground live carbon pool of more than 25 percent. The nearly 14-percent increase in the understory carbon pool is tied to a general shift toward younger tree cohorts. Carbon pool shifts from 1990 to 2020 are shown in figure 1.

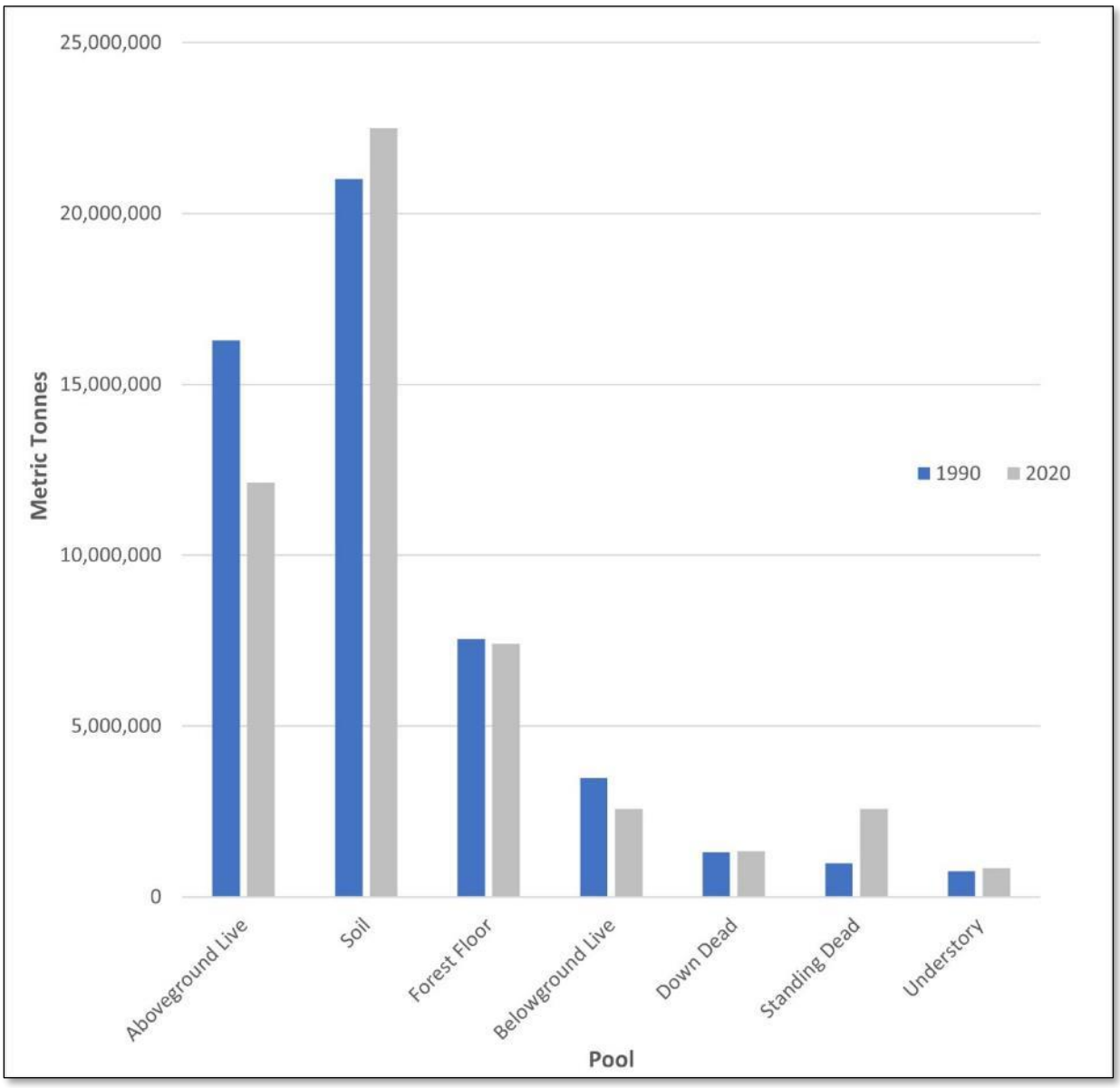

Figure 1. Above- and below-ground carbon pool, 1990 and 2020

The description of forest carbon stocks and fluxes above highlights the role of disturbances, management, and environmental factors in influencing carbon dynamics the Black Hills National Forest and elsewhere across the region. However, climate change introduces additional uncertainty about how vegetation—and vegetation carbon uptake and storage—may change in the future. Climate change causes direct alterations of the local environment, including temperature and precipitation, and indirectly affects a wide range of ecosystem processes (Vose et al. 2012), including vegetation growth, regeneration, and mortality. Because disturbance regimes are projected to increase with climate change (Vose et al. 2018), understanding past trends is not sufficient to fully understand vegetation carbon dynamics in the future.

Climate and environmental factors, including elevated atmospheric carbon dioxide and nitrogen deposition, have also influenced carbon accumulation in the Black Hills National Forest. These factors have enhanced growth rates and helped to counteract ecosystem carbon losses due to disturbance. The effects of future climate conditions are complex and remain uncertain. However, under changing climate and environmental conditions, forests in the Black Hills may be increasingly vulnerable to a variety of stressors. These potentially negative effects might be balanced somewhat by the positive effects of a longer growing season, greater precipitation, and elevated atmospheric carbon dioxide concentrations. However, it is difficult to judge how these factors and their interactions will affect future carbon dynamics in the Black Hills National Forest.

Anecdotal and semi-quantitative analysis associated with natural and human-caused trends in disturbance in the Black Hills predicted the decrease in stored carbon pools. Although future changes in climatic factors will be highly variable, thoughtful carbon stewardship that optimizes carbon, along with simultaneous maintenance of ecosystem integrity, together will stabilize carbon in the long term.

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