Executive Summary
Governing Uranium in the United States

In 2013 CSIS participated in the Governing Uranium project, which sought to identify governance gaps in the front end of the nuclear fuel cycle, including uranium mining, milling and conversion. The Proliferation Prevention Program at CSIS focused specifically on the United States, highlighting best practices when it comes to accounting for and protecting uranium.

Early History to Present Day
The United States has been a major producer and consumer of uranium over the years, both for nuclear weapons and for peaceful purposes, and for domestic and international consumption. In the past two decades, the United States has been eclipsed by Australia, Canada, and Kazakhstan. However, with roughly 100 operating nuclear power reactors, it continues to have a major appetite for enriched uranium (about 22 million kilograms of U3O8 equivalent in 2012).¹

Before U.S. officials recognized uranium’s strategic importance for nuclear weapons production, its mining and handling was treated no differently from those of other ores. As uranium’s strategic importance became apparent, the U.S. government sought to control not only uranium supplies within the United States, but elsewhere (particularly in Canada and Africa). At their most restrictive, however, U.S. uranium controls never extended into mining, but were limited to milling and enrichment ownership by the U.S. government. A decade of simultaneous government promotion and strict control lasted until the mid-1950s, after which military demand for uranium declined, prompting a gradual easing of controls over both domestic production and foreign imports.

The uranium market fell into decline in the 1960s, but with the growth of commercial nuclear power over the next decade, demand for uranium in the United States once again grew. This brought a further relaxation of controls over mining and the use of foreign-origin uranium, with an effective government embargo phased out between 1977 and 1984. The loosening of restrictions devastated the domestic production industry, which saw output and employment at mills and mines plunge.

The domestic uranium industry somewhat recovered from its nadir in the 1980s and early 1990s as the price of uranium rose in the mid-to-late 2000s. However, this recovery occurred in the production of concentrate rather than in mined ore. In 2011, 1.9 million kilograms of U₃O₈ was produced by five in-situ leaching (ISL) plants and the White Mesa Mill in Utah, with ore supplied by five conventional underground mines. The White Mesa Mill has been the sole operating conventional mill since 2005, and since June 2013 it has only been processing alternate feeds.

In addition to domestic production, the United States imports approximately 25 million kilograms of uranium in various forms annually, which in 2012 made up 83 percent of deliveries to U.S. operators. U.S. purchases of foreign uranium rose significantly after the end of the Cold War, from 13.9 million kilograms in 1993 to 21.6 million kilograms in 2012. While the U.S.-Russian high-enriched uranium (HEU) downblending agreement played a large role in this, new entrants on the supply side in countries such as Namibia, Niger, and Malawi, and in the former Soviet Union (e.g., Kazakhstan and Uzbekistan) were also a factor. In 2012, Australia and Canada accounted for 35 percent of total supply; Kazakhstan, Russia, and Uzbekistan provided 29 percent; and the

remaining 19 percent came from Brazil, China, Malawi, Namibia, Niger, South Africa, and Ukraine. In all, U.S. civilian nuclear power reactors purchased uranium for 2012 deliveries from 32 sellers.

By the 1970s, the government largely shifted the focus of its controls from maintaining the economic well-being of the industry to ensuring public and worker safety and protecting the environment. This shift was accompanied by the establishment of the Department of Energy (DOE) and the Nuclear Regulatory Commission (NRC). The greatest impact on the front end of the fuel cycle came arguably from the 1978 Uranium Mill Tailings Radiation Control Act (UMTRCA), which enacted stricter controls over uranium to improve environmental and safety performance at uranium mines and mills. Safety and environmental concerns have dominated improvements in governance since then. Although they played a key role in the mid-1940s, security concerns have not been a motivating force for change in uranium governance in the United States since about the mid-1950s, even after September 11, 2001.

Risk Assessment
Along the production chain for fissile material, uranium ore ranks dead last in terms of its attractiveness for a bomb because it must go through many processes before it is usable. However, the more processed the material, the greater the risk of detection. Those seeking to acquire capabilities clandestinely often seek the path of least resistance and natural uranium could therefore be attractive to a country or nonstate actor determined to build a nuclear weapon.

The two basic pathways for obtaining uranium illegally are through outright theft or illicit diversion. Either way, insider involvement would considerably boost the chances of success. Moving material to illicit overseas destinations would almost certainly involve falsifying export control documents, such as material declarations, end uses, and end users. First- and second-stage barriers to such activities are on-site security and transport monitoring. Vigilance by export control agencies is a third barrier, particularly when it comes to spotting falsified documents or other evidence suggesting illegal trafficking. Theft scenarios could include: ore stockpiles at the mining site, ore in transit to milling, yellowcake at milling, yellowcake en route to conversion, yellowcake and/or UF6 in storage at conversion sites, and UF6 en route to enrichment.

The International Atomic Energy Agency (IAEA) “significant quantity” for natural uranium (an indirect use material) is 10 tons. At 1 percent grade, the amount of ore required to produce 10 tons of natural uranium would be 1,000 tons. That 10 tons of natural uranium can produce roughly 45 kilograms of HEU (with significant variations according to tails assays). Ten tons of natural uranium would also yield roughly 10 kilograms of Pu.

Outright theft of ore is an unattractive proposition; large amounts would be required and detection would be fairly easy. Theft at a conventional mill or ISL plant is more attractive than theft of ore, given that much less yellowcake is needed to produce a significant quantity of fissile material. However, conventional mill sites tend to be much more secure than mines, given their continuous hours of operation and relatively increased level of physical protection and security measures.

Only one truck would need to be stolen en route to the conversion plant in order to acquire one SQ of natural uranium, assuming a 40-foot truck trailer that can hold up to 60 drums. It is more likely that such material would be stolen during transport, rather than at the mill site. This is because the material has already been packaged and prepared, and is outside the confines of the milling facility. Theft during transportation of unenriched UF6 might also be viewed as attractive, given that one Type 48Y canister holds nearly enough uranium for one SQ. However, theft of such a truck would be arguably more conspicuous than theft of a truck containing yellowcake.

**Diversion scenarios** assume there are one or more insiders in a facility who can evade detection and/or security measures. One possibility is to manipulate material accounting in order to disguise an illicit diversion to allow for clandestine shipments later. In fact, state employees in Kazakhstan allegedly made a clandestine deal, without approval of the Kazakh government, to sell 1,350 tons of yellowcake to Iran, taking advantage of overproduction and poor accounting of uranium output.\(^3\) Falsifying export control documents, such as material declarations, end-use, or end-user certificates, constitutes another pathway for illicit shipments. Finally, another route could involve deception regarding the ultimate end user, possibly involving unwitting suppliers and middlemen.\(^4\)

**U.S. Regulation and Reporting**
The bulk of source material regulation falls primarily under the authority of the Nuclear Regulatory Commission (NRC). The NRC, however, does not regulate conventional mining, which is subject to the 1872 Mining Act. Regulation is further complicated by the federalist nature of the Agreement State system, which allows some states to perform regulatory functions that the NRC otherwise would perform. This framework, combined with issues regarding public land ownership, tribal authorities, and environmental concerns, complicates the regulatory framework for uranium recovery operations.

Since natural uranium is not “special nuclear material,” there are no physical protection requirements of the NRC specifically targeted at uranium recovery facilities for source material, although there are some physical protection requirements during transit. Most of the physical protection measures are self-imposed by industry out of economic interest.

Despite this, there are several barriers to potential theft. Uranium recovery operations take place in fairly remote locations, which itself is an inherent barrier to theft. U.S. uranium producers tend to use armed guards at their mills, including 24-hour surveillance and barbed wire fences, although this is not universal, especially at in-situ leach (ISL) facilities.

Physical protection practices during transportation tend to be more rigorous than during production at mill sites. Transporters take precautions to ensure timely delivery of uranium, which can include designated routes with designated rest stops, additional drivers, and global positioning system (GPS) tracking on trucks to monitor engine conditions and speeds. There are also seals on the trailer to detect tampering, with verification of container numbers when the transport reaches its destination. Most transportation requirements for source material arise from safety considerations.

The Department of Transportation (DOT) also harmonizes with IAEA guidelines for transportation of uranium in its different forms. While transportation of placarded UF6 requires a security plan, yellowcake and ore are treated as very low risk. There are also distinct DOT regulations for different types of transportation—rail, ship, air, or highway—of Class 7 radioactive materials, which covers a broad range of materials that emit radiation. On the whole, it is unclear how often these regulations are enforced. Inspections requirements aim to establish whether material has been correctly packaged and labeled, rather than to verify the material itself. Noncompliance with DOT regulations can result in a fine and possible jail time.

NRC regulations reveal the extent to which the theft or diversion of source material is considered a risk: the NRC requires a report from specific license holders when an attempt of theft or unlawful diversion is made of source material.

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\(^4\) These kinds of techniques reportedly were used in the Plumbat operation in the early 1960s to divert yellowcake within Europe to Israel.
material above 15 pounds within four hours of knowledge of the incident. This system does not allow for reports to be made public, and there is no available information about whether thefts have been reported under it. This requirement is largely one of self-reporting; there do not appear to be repercussions for the industry if it does not report thefts. There is no system in the United States for determining the amount of unaccounted for source material.

The United States has extensive international reporting commitments because of its treaty and other voluntary obligations. It has had a Safeguards Agreement in force with the IAEA since 1980 and an Additional Protocol Agreement since 2009. The Safeguards Agreement states that IAEA safeguards do not apply to material in mining or ore processing activities. With respect to reporting exports and imports, the United States, the Soviet Union, and the United Kingdom informed the IAEA in 1974 that they would report exports to non-nuclear-weapon states of nuclear material exceeding one effective kilogram and imports of such material from states where it was subject to IAEA safeguards right before its export. In 1995 the U.S. government agreed to voluntarily report imports and exports of one kilogram or more of source material (natural uranium, depleted uranium, and thorium) to the IAEA on a monthly basis.

Conclusions
As a nuclear weapon state, with significant production facilities and no international requirements for uranium accounting and control, U.S. practices in controlling uranium production, storage, transport, and use may not be the model for emulation by other states. To be fair, there are clearly more significant targets for material theft or diversion in the United States than existing mining and milling facilities, such as the nuclear weapons stockpile, material in weapons awaiting dismantlement and in fissile material stockpiles, and in active and mothballed production facilities. Although more attractive, these targets are more heavily guarded and subject to much more stringent accounting and control procedures than are commercial uranium mines and uranium recovery facilities. Nonetheless, the evolution of control in the United States may indicate some useful leverage points for other countries currently or potentially engaged in uranium mining.

Some measures to improve uranium accounting could include: provision of data about ore production (e.g. monthly, quarterly, or yearly) rather than estimated production; application of security measures such as “geofencing,” tracking trailers as well as cabs, barcoding drums of yellowcake or cylinders of uranium hexafluoride (UF6); and improved uranium chain of custody at conversion plant. In the United States specifically, measures to enforce consequences if Nuclear Materials Management & Safety System (NMMSS) or NRC inspections reveal discrepancies would be useful.

5 Code of Federal Regulations, NRC Regulations, 10, Sec. 40.64(c).