Chapter 7: Scientific Progress Expected over the Next Decade

Substantial progress has been made in climate change science during the two decades since the Intergovernmental Panel on Climate Change (IPCC) issued its first assessment report in 1990. That IPCC First Assessment Report (FAR) included 10 pages on effects of climate change on ecosystems, none of which included fire (Melillo et al. 1990; Houghton, Callander, and Varney 1992). By the 2007 release of the fourth (AR4) IPCC assessment report (IPCC WG I 2007), much of the overall uncertainty concerning climate change had been resolved, most Earth system components were being included in ever more exacting numerical models, and impacts of climate change were receiving greater attention (IPCC WG II 2007). In the 4 years since the AR4 release, scientific progress in areas of more immediate applicability to fire management has been substantial. More than 40% of the ~ 1000 papers[31] refernced in this synthesis have been published since the release of AR4. With strong consensus answers to most of the scientific questions regarding the basic drivers of global climate change, and models that are continually improving in terms of both process inclusion and spatial-temporal resolution, a greater portion of scientific effort is being directed to ecosystem (including fire) impacts and the climate processes that affect them. We see particular opportunity for scientific advancement in the decade ahead in the areas of: paleo fire history; quantification of burned areas, fire severity, fire emissions, smoke transport and deposition; climate effects on fire regimes; feedbacks of changing fire regimes to climate, carbon and ecosystem processes; climate change forcing of ecoregion change at longer time scales; climate change effects of other ecosystem disturbances, forest health, and invasive species; improved forecasts of annual to interannual climate variability associated with various coupled atmosphere-ocean circulation oscillations such as ENSO (El Nino-Southern Oscillation); and enhancement of ecosystem monitoring capabilities to record climate change impacts (Lowman et al. 2009). These and other areas of scientific progress will combine in different ways to aid managers at the Short (synoptic to seasonal), Intermediate (annual to interannual) and Long (decadal to centennial) time scales discussed in Chapter 5 (McKenzie et al. 2011). These time scales are roughly equivalent to those used for Land Management Planning (LMP), Seasonal to interannual fire planning and incident management and recovery (Simard 1991; Christensen 1989; Lessard 1998; Neary et al. 2000; Hann and Bunnell 2001; Roads et al. 2005).

Expected Scientific Progress for use at Long (decadal to centennial) time scales

Continuing incremental progress is expected in General Circulation Models (GCMs) used for climate change projections, especially in connection with release of the Fifth Assessment Report (AR5) of the Intergovernmental Panel on Climate Change (IPCC) expected in 2014 (Hulme et al. 2010). In addition to improvement in resolution, inter-model comparability and multiple Earth system processes, a scheduled upgrade of emission factor scenario inputs will be included (Moss et al. 2010; Thomson et al. 2011). Since there appears little likelihood of new international agreements aimed at mitigating climate change, business as usual emissions projections are

[31] The online Fire History and Climate Change bibliographic data base may be accessed at: https://www.zotero.org/groups/jfsp_fire_history_and_climate_change/items/order/creator

increasingly likely to be accurate and of greater utility for long term planning (Schmittner et al. 2008). Increasing accuracy of long-term climate projections will result in better input for ecosystem change projections of what species and distributions future climate is likely to support, including for reanalysis of Bailey ecosystem classifications to adjust them to future climate conditions (Monserud and Leemans 1992; Sala 2000; Iverson and Prasad 2002; Saxon et al. 2005). These projections of future ecosystem composition at the Bailey Division/Province/Sector levels will afford fire managers the opportunity to respond to fire with knowledge of likely post-fire ecosystem response given future climate (Hannah et al. 2002; Fulé 2008; Stephens et al. 2010; Sandel and Dangremond 2011). Higher resolution and broader scale data gained from an increasing array of paleo-fire information sources and information management advances is improving the utility of fire history knowledge. Combining improved long-term climate projections with this improved fire history knowledge of fire-ecosystem changes during similar past climate will greatly help fire managers plan for climate change in areas where paleo-fire information is available (Swetnam 1993; Swetnam et al. 1998; Grissino Mayer and Swetnam 2000; Whitlock et al. 2003; Hessl et al. 2004; Schoennagel et al. 2004). For areas of the country where fire history is either not plentiful or where future fire regimes have no historic analogue, managers will gain some advantage by matching future ecosystems in their locale with analogous ecosystems and their historic fire regimes from other regions (Emanuel et al. 1985; Dale et al. 2001; Mouillot et al. 2002; Mouillot and Field 2005).

Expected Scientific Progress for use at Intermediate (annual to interannual) time scales

We expect significant scientific progress at the Intermediate time scale because of improved observation and understanding of the atmosphere-ocean circulation patterns forcing interannual atmospheric variability; prospects of significantly improved climate forecasts at these scales; and major advancements in the understanding of how atmospheric variability at this scale does and does not impact regional scale fire and fire regimes. Scientists have demonstrated teleconnections between variability in fire regimes and oscillating atmosphere-ocean circulation patterns, such as El Nino Southern Oscillation (ENSO) (Simard et al. 1985; Biondi et al. 2001; Hessl et al. 2004; Taylor and Beaty 2005; Kitzberger et al. 2007; Trouet et al. 2006; Le Goff et al. 2007). The observation, understanding and predictability of ENSO and related oscillatory patterns have shown remarkable advancement for a wide variety of climate ecosystem linked processes (Brenner 1991; Trenberth and Hoar 1997; Beckage et al. 2003; Alencar et al. 2006; Benson et al. 2008; Carmona-Moreno et al. 2005; Collins et al. 2010; Goodrick and Hanley 2009; Greenville et al. 2009; Galeotti et al. 2010; Trouet and Taylor 2010; Kasischke et al. 2010; Williams et al. 2010; Yocom et al. 2010; Lean and Rind 2009; Lanning et al. 2010; Dai 2011). The combination of improvements in climate forecasts and quantification of effects of annual to interannual climate variability on fire should yield significant advances for fire planning in the decade ahead.

Expected Scientific Progress for use at Short (synoptic to seasonal) time scales

Advances in climate prediction at Long time scales are not as likely as for the Intermediate scales over the next decade, although decadal prediction is receiving attention (Keenlyside and Ba 2010). At long time scales uncertainty with projections of future GHG emissions resulting from inability to determine sociopolitical drivers in the advance of international climate change governance outweighs uncertainty associated with the GCMs themselves. However, improvements in our understanding of how ecosystems will respond to future climate change under business as usual emission scenarios are likely to take place. Both ecosystem and satellite based observing systems are building databases to help monitor and describe how ecosystems are responding to ongoing climate change. The potential exists to employ ongoing LANDFIRE updates to focus this ecosystem information on fire regime changes. To achieve this, the fire community needs to assure that LANDFIRE and other nationally consistent efforts developed over the last decade or so are maintained and updated. It would also be beneficial to have a nationally consistent fire regime classification system with agreed to criteria and measurable indicators available for applying more general ecosystem/climate change observation to fire business.